



Full wwPDB X-ray Structure Validation Report ⓘ

Feb 1, 2016 – 12:34 AM GMT

PDB ID : 2AY3
Title : AROMATIC AMINO ACID AMINOTRANSFERASE WITH 3-(3,4-DIMETHOXYPHENYL)PROPIONIC ACID
Authors : Okamoto, A.; Hirotsu, K.; Kagamiyama, H.
Deposited on : 1998-08-06
Resolution : 2.40 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
<http://wwpdb.org/validation/2016/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 : 1.7 (RC4), CSD as536be (2015)
Xtriage (Phenix) : **NOT EXECUTED**
EDS : **NOT EXECUTED**
Percentile statistics : 20151230.v01 (using entries in the PDB archive December 30th 2015)
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : trunk26865

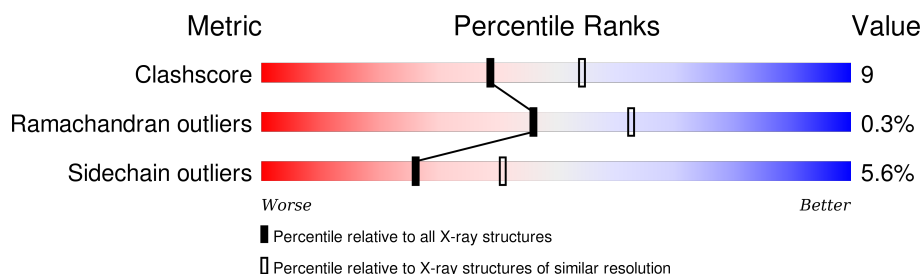
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.40 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	102246	3407 (2.40-2.40)
Ramachandran outliers	100387	3351 (2.40-2.40)
Sidechain outliers	100360	3352 (2.40-2.40)

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. 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 $\leq 5\%$. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density. The numeric value is given above the bar.

Note EDS was not executed.

Mol	Chain	Length	Quality of chain
1	A	394	 83% 16% •
1	B	394	 73% 24% • •

2 Entry composition [i](#)

There are 4 unique types of molecules in this entry. The entry contains 6325 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 AROMATIC AMINO ACID AMINOTRANSFERASE.

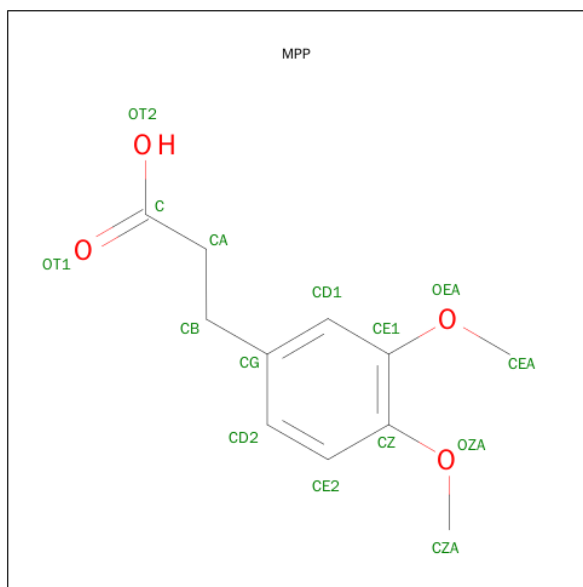
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	394	Total	C	N	O	S	0	0	0
			2996	1884	527	565	20			
1	B	388	Total	C	N	O	S	0	0	0
			2945	1855	514	556	20			

- Molecule 2 is PYRIDOXAL-5'-PHOSPHATE (three-letter code: PLP) (formula: $C_8H_{10}NO_6P$).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	A	1	Total	C	N	O	P	0	0
			15	8	1	5	1		
2	B	1	Total	C	N	O	P	0	0
			15	8	1	5	1		

- Molecule 3 is 3-(3,4-DIMETHOXYPHENYL)PROPIONIC ACID (three-letter code: MPP) (formula: $C_{11}H_{14}O_4$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total	C	O	0	0
			15	11	4		
3	B	1	Total	C	O	0	0
			15	11	4		

- Molecule 4 is water.

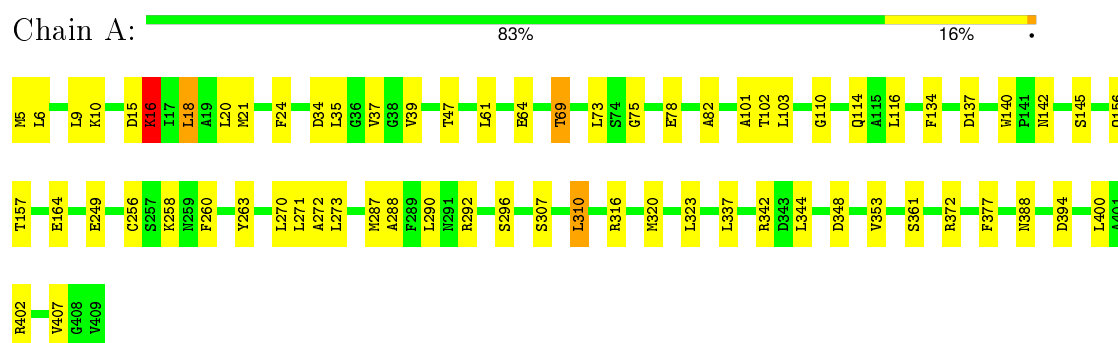
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	174	Total	O	0	0
			174	174		
4	B	150	Total	O	0	0
			150	150		

3 Residue-property plots [i](#)

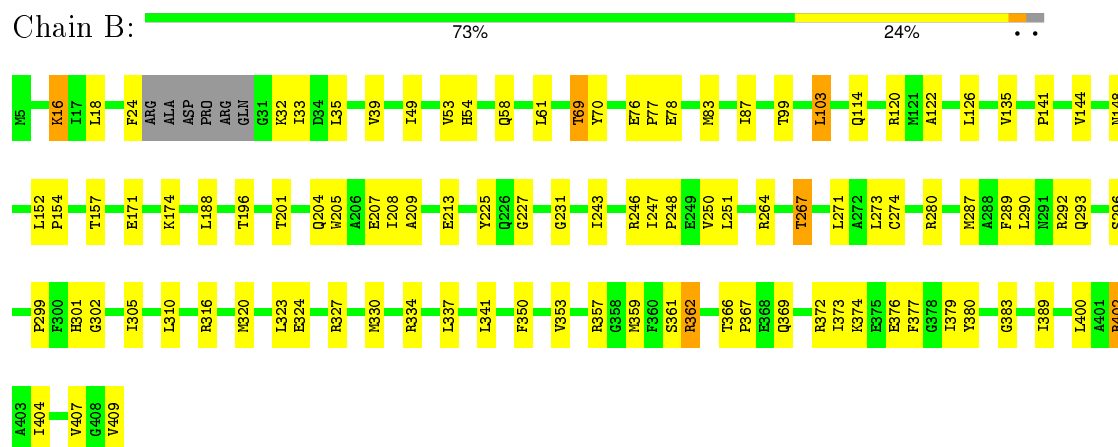
These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of errors displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. Residues are color-coded according 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. A red dot above a residue indicates a poor fit to the electron density ($RSRZ > 2$). 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: AROMATIC AMINO ACID AMINOTRANSFERASE



• Molecule 1: AROMATIC AMINO ACID AMINOTRANSFERASE



4 Data and refinement statistics

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

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	123.87Å 121.69Å 55.23Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	6.00 – 2.40	Depositor
% Data completeness (in resolution range)	78.3 (6.00-2.40)	Depositor
R_{merge}	0.09	Depositor
R_{sym}	(Not available)	Depositor
Refinement program	X-PLOR 3.1	Depositor
R, R_{free}	0.164 , 0.221	Depositor
Estimated twinning fraction	No twinning to report.	Xtriage
Total number of atoms	6325	wwPDB-VP
Average B, all atoms (Å ²)	25.0	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: MPP, PLP

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	0.36	0/3048	0.60	0/4119
1	B	0.35	0/2995	0.61	1/4046 (0.0%)
All	All	0.35	0/6043	0.61	1/8165 (0.0%)

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	188	LEU	CA-CB-CG	6.25	129.67	115.30

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	2996	0	3004	44	0
1	B	2945	0	2953	72	0
2	A	15	0	7	0	0
2	B	15	0	7	1	0
3	A	15	0	13	0	0
3	B	15	0	13	1	0
4	A	174	0	0	4	0
4	B	150	0	0	5	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
All	All	6325	0	5997	108	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 9.

All (108) 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:B:16:LYS:H	1:B:16:LYS:HD3	1.33	0.94
1:B:337:LEU:HD12	1:B:353:VAL:HG11	1.63	0.80
1:B:120:ARG:HD3	1:B:152:LEU:HD11	1.68	0.75
1:A:47:THR:HG21	1:B:69:THR:HG23	1.67	0.75
1:A:292:ARG:HA	1:A:296:SER:HA	1.70	0.74
1:B:330:MET:HB3	1:B:389:ILE:HD11	1.69	0.73
1:B:267:THR:HG21	1:B:302:GLY:HA3	1.70	0.72
1:B:33:ILE:HG22	1:B:35:LEU:HD13	1.72	0.72
1:B:103:LEU:HG	1:B:287:MET:HB3	1.71	0.70
1:B:373:ILE:HA	1:B:377:PHE:HD2	1.56	0.69
1:A:61:LEU:HD21	1:B:58:GLN:HG2	1.77	0.67
1:B:366:THR:HB	1:B:367:PRO:HD2	1.76	0.66
1:B:16:LYS:HE2	1:B:141:PRO:HB3	1.79	0.65
1:B:373:ILE:HG22	1:B:379:ILE:HG23	1.78	0.65
1:A:78:GLU:HG2	1:A:307:SER:HB2	1.80	0.64
1:B:196:THR:HA	1:B:362:ARG:HG3	1.82	0.61
1:A:9:LEU:HD13	1:B:122:ALA:HB2	1.82	0.61
1:A:16:LYS:HG2	4:A:517:HOH:O	2.00	0.61
1:A:137:ASP:HB2	1:A:157:THR:HG23	1.82	0.60
1:B:174:LYS:HD3	1:B:207:GLU:HG2	1.83	0.60
1:B:373:ILE:HA	1:B:377:PHE:CD2	2.38	0.59
1:B:404:ILE:O	1:B:407:VAL:HG12	2.03	0.59
1:B:225:TYR:HE2	2:B:413:PLP:HO3	1.49	0.58
1:A:15:ASP:O	1:A:16:LYS:HB2	2.02	0.58
1:B:316:ARG:O	1:B:320:MET:HG3	2.04	0.57
1:A:137:ASP:HB2	1:A:157:THR:CG2	2.34	0.57
1:A:134:PHE:CE2	1:A:156:GLN:HG2	2.40	0.57
1:B:205:TRP:HE3	1:B:243:ILE:HD11	1.70	0.56
1:B:292:ARG:HA	1:B:296:SER:HA	1.88	0.55
1:B:373:ILE:CG2	1:B:379:ILE:HG23	2.38	0.54
1:A:110:GLY:O	1:A:114:GLN:HG2	2.07	0.54
1:A:114:GLN:HA	1:A:114:GLN:HE21	1.74	0.53
1:A:6:LEU:O	1:A:9:LEU:HB2	2.09	0.52

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:372:ARG:O	1:B:376:GLU:HG2	2.09	0.52
1:A:37:VAL:HG23	1:A:388:ASN:HD22	1.74	0.52
1:A:342:ARG:HH22	1:A:348:ASP:HB3	1.75	0.52
1:B:24:PHE:CE1	1:B:32:LYS:HB3	2.45	0.51
1:A:407:VAL:HG12	1:A:407:VAL:O	2.08	0.51
1:B:87:ILE:HD12	1:B:271:LEU:HD11	1.93	0.51
1:A:24:PHE:CE1	1:A:34:ASP:HB2	2.46	0.51
1:A:101:ALA:HB3	1:A:272:ALA:HB3	1.93	0.50
1:A:342:ARG:NH2	1:A:348:ASP:HB3	2.26	0.50
1:B:18:LEU:HD11	3:B:414:MPP:HZA2	1.94	0.50
1:B:400:LEU:O	1:B:404:ILE:HG23	2.13	0.49
1:B:301:HIS:O	1:B:305:ILE:HG13	2.13	0.49
1:A:73:LEU:HD23	1:A:288:ALA:HB1	1.93	0.48
1:A:316:ARG:O	1:A:320:MET:HG3	2.14	0.48
1:B:225:TYR:HE1	1:B:359:MET:HE1	1.78	0.48
1:B:402:ARG:HH11	1:B:402:ARG:HG2	1.78	0.48
1:A:256:CYS:O	1:A:260:PHE:HB2	2.14	0.48
1:A:140:TRP:CE3	1:A:142:ASN:HB2	2.48	0.47
1:B:33:ILE:HB	1:B:379:ILE:HB	1.96	0.47
1:A:102:THR:HG23	1:A:271:LEU:HD23	1.95	0.47
1:A:69:THR:CG2	1:B:39:VAL:HG11	2.44	0.47
1:A:82:ALA:HB1	1:A:310:LEU:HD23	1.97	0.47
1:B:231:GLY:HA2	1:B:327:ARG:NH1	2.30	0.47
1:A:342:ARG:HH12	1:A:348:ASP:HB2	1.79	0.47
1:A:342:ARG:HH12	1:A:348:ASP:CB	2.28	0.46
1:A:249:GLU:HA	1:A:273:LEU:O	2.15	0.46
1:B:204:GLN:O	1:B:208:ILE:HG12	2.15	0.46
1:B:49:ILE:HG21	4:B:424:HOH:O	2.14	0.46
1:A:10:LYS:HA	1:A:10:LYS:HE2	1.97	0.46
1:A:337:LEU:HD23	1:A:353:VAL:HG11	1.98	0.46
1:A:164:GLU:HB2	4:A:533:HOH:O	2.14	0.46
1:A:372:ARG:HD2	1:A:407:VAL:HG13	1.98	0.46
1:A:16:LYS:O	1:A:20:LEU:HG	2.16	0.45
1:B:16:LYS:H	1:B:16:LYS:CD	2.12	0.45
1:A:377:PHE:HE1	1:A:402:ARG:HE	1.63	0.45
1:B:379:ILE:HD11	1:B:400:LEU:HD13	1.98	0.45
1:A:37:VAL:HG23	1:A:388:ASN:ND2	2.31	0.45
1:B:201:THR:OG1	1:B:204:GLN:HG3	2.17	0.45
1:B:324:GLU:OE1	1:B:327:ARG:NH1	2.50	0.45
1:B:152:LEU:HA	1:B:154:PRO:HD3	1.85	0.44
1:B:330:MET:O	1:B:334:ARG:HG3	2.16	0.44

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:334:ARG:NH2	1:B:361:SER:HB2	2.31	0.44
1:A:5:MET:HE3	1:B:122:ALA:HB3	1.99	0.44
1:B:327:ARG:HD2	4:B:503:HOH:O	2.18	0.44
1:A:39:VAL:HG21	1:B:69:THR:CG2	2.48	0.44
1:B:35:LEU:HD22	1:B:379:ILE:HD11	1.99	0.44
1:B:341:LEU:HD13	1:B:350:PHE:CD2	2.53	0.43
1:B:99:THR:HB	1:B:274:CYS:O	2.19	0.43
1:A:15:ASP:HB2	1:A:18:LEU:HD12	2.00	0.43
1:B:247:ILE:HA	1:B:248:PRO:HD2	1.83	0.43
1:B:299:PRO:HB2	4:B:515:HOH:O	2.18	0.43
1:A:103:LEU:HD13	1:A:287:MET:HB3	2.00	0.43
1:A:69:THR:HG23	1:B:39:VAL:HG11	2.01	0.42
1:B:374:LYS:HE2	1:B:380:TYR:HD1	1.84	0.42
1:B:53:VAL:HG13	1:B:305:ILE:HG21	2.00	0.42
1:B:144:VAL:HG12	1:B:148:ASN:ND2	2.34	0.42
1:B:273:LEU:N	1:B:273:LEU:HD23	2.34	0.42
1:B:24:PHE:HD1	1:B:380:TYR:CD2	2.38	0.42
1:B:323:LEU:HG	1:B:327:ARG:HH21	1.84	0.42
1:B:54:HIS:HD2	4:B:424:HOH:O	2.02	0.42
4:A:429:HOH:O	1:B:264:ARG:HD2	2.19	0.42
1:B:16:LYS:HE2	1:B:141:PRO:CB	2.48	0.42
1:B:209:ALA:O	1:B:213:GLU:HG2	2.20	0.41
1:B:205:TRP:CE3	1:B:243:ILE:HD11	2.52	0.41
1:B:369:GLN:NE2	1:B:409:VAL:HA	2.36	0.41
1:B:24:PHE:HD1	1:B:380:TYR:CE2	2.38	0.41
1:A:258:LYS:HG3	1:A:263:TYR:CE2	2.55	0.41
1:B:227:GLY:O	1:B:327:ARG:NE	2.51	0.41
1:B:76:GLU:HA	1:B:77:PRO:HD3	1.93	0.41
1:A:75:GLY:HA2	4:A:425:HOH:O	2.20	0.41
1:B:32:LYS:NZ	1:B:32:LYS:HB2	2.36	0.40
1:A:263:TYR:HB3	1:B:70:TYR:CD1	2.56	0.40
1:B:135:VAL:O	1:B:157:THR:HA	2.21	0.40
1:B:83:MET:SD	4:B:553:HOH:O	2.63	0.40
1:B:289:PHE:O	1:B:293:GLN:HG2	2.21	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	392/394 (100%)	380 (97%)	11 (3%)	1 (0%)	46	63
1	B	384/394 (98%)	360 (94%)	23 (6%)	1 (0%)	46	63
All	All	776/788 (98%)	740 (95%)	34 (4%)	2 (0%)	46	63

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	16	LYS
1	B	383	GLY

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	308/308 (100%)	292 (95%)	16 (5%)	29	45
1	B	303/308 (98%)	285 (94%)	18 (6%)	24	38
All	All	611/616 (99%)	577 (94%)	34 (6%)	26	41

All (34) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	16	LYS
1	A	18	LEU
1	A	21	MET
1	A	35	LEU

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Mol	Chain	Res	Type
1	A	64	GLU
1	A	69	THR
1	A	116	LEU
1	A	145	SER
1	A	270	LEU
1	A	290	LEU
1	A	310	LEU
1	A	323	LEU
1	A	344	LEU
1	A	361	SER
1	A	394	ASP
1	A	400	LEU
1	B	16	LYS
1	B	61	LEU
1	B	69	THR
1	B	78	GLU
1	B	103	LEU
1	B	114	GLN
1	B	126	LEU
1	B	171	GLU
1	B	246	ARG
1	B	250	VAL
1	B	251	LEU
1	B	267	THR
1	B	280	ARG
1	B	290	LEU
1	B	310	LEU
1	B	357	ARG
1	B	362	ARG
1	B	402	ARG

Some 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	114	GLN
1	B	54	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$
2	PLP	A	413	1	15,15,16	2.27	2 (13%)	21,22,23	2.17	5 (23%)
3	MPP	A	414	-	12,15,15	1.70	2 (16%)	16,19,19	1.79	4 (25%)
2	PLP	B	413	1	15,15,16	2.10	3 (20%)	21,22,23	1.81	2 (9%)
3	MPP	B	414	-	12,15,15	1.67	2 (16%)	16,19,19	1.81	4 (25%)

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	PLP	A	413	1	-	0/6/6/8	0/1/1/1
3	MPP	A	414	-	-	0/7/9/9	0/1/1/1
2	PLP	B	413	1	-	0/6/6/8	0/1/1/1
3	MPP	B	414	-	-	0/7/9/9	0/1/1/1

All (9) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	413	PLP	C4A-C4	-6.38	1.38	1.51
2	B	413	PLP	C4A-C4	-5.53	1.40	1.51

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	B	413	PLP	C3-C2	-4.86	1.37	1.40
2	A	413	PLP	C3-C2	-4.48	1.37	1.40
3	B	414	MPP	OZA-CZA	-3.92	1.30	1.42
3	A	414	MPP	OEA-CEA	-3.88	1.31	1.42
3	B	414	MPP	OEA-CEA	-3.74	1.31	1.42
3	A	414	MPP	OZA-CZA	-3.73	1.31	1.42
2	B	413	PLP	P-O2P	2.47	1.63	1.54

All (15) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	414	MPP	CZA-OZA-CZ	-4.72	110.38	117.54
3	B	414	MPP	CZA-OZA-CZ	-4.40	110.86	117.54
2	A	413	PLP	O2P-P-O4P	-3.86	95.45	106.56
3	B	414	MPP	CEA-OEA-CE1	-3.65	112.01	117.54
3	A	414	MPP	CEA-OEA-CE1	-3.57	112.13	117.54
3	A	414	MPP	OZA-CZ-CE2	-2.36	120.38	124.35
3	B	414	MPP	OZA-CZ-CE2	-2.27	120.54	124.35
2	A	413	PLP	C5-C6-N1	-2.04	120.33	123.86
2	B	413	PLP	C6-C5-C4	2.00	119.85	118.15
2	A	413	PLP	C6-C5-C4	2.14	119.96	118.15
3	A	414	MPP	OZA-CZ-CE1	2.67	119.21	115.40
3	B	414	MPP	OZA-CZ-CE1	2.95	119.61	115.40
2	A	413	PLP	O3P-P-O1P	3.01	120.28	110.58
2	B	413	PLP	O4P-C5A-C5	6.54	119.81	108.99
2	A	413	PLP	O4P-C5A-C5	7.39	121.21	108.99

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

2 monomers are involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	B	413	PLP	1	0
3	B	414	MPP	1	0

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 [i](#)

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

EDS was not executed - this section will therefore be empty.

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

EDS was not executed - this section will therefore be empty.

6.3 Carbohydrates [i](#)

EDS was not executed - this section will therefore be empty.

6.4 Ligands [i](#)

EDS was not executed - this section will therefore be empty.

6.5 Other polymers [i](#)

EDS was not executed - this section will therefore be empty.