



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 7, 2026 – 02:26 AM UTC

PDB ID : 3PCA / pdb_00003pca
Title : STRUCTURE OF PROTOCATECHUATE 3,4-DIOXYGENASE COM-
PLEXED WITH 3,4-DIHYDROXYBENZOATE
Authors : Orville, A.M.; Lipscomb, J.D.; Ohlendorf, D.H.
Deposited on : 1997-07-18
Resolution : 2.20 Å (reported)

This is a wwPDB X-ray Structure Validation Summary 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**
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

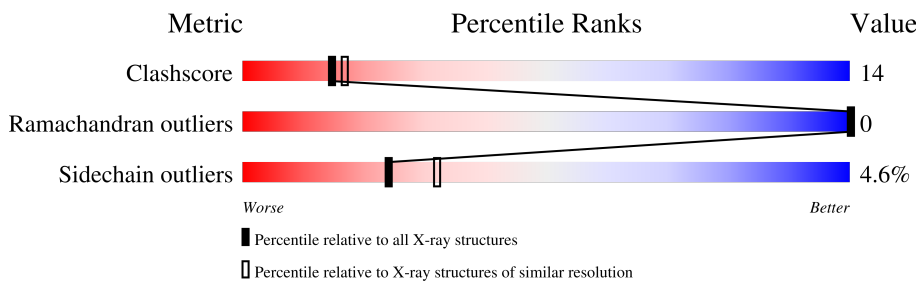
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.20 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	6851 (2.20-2.20)
Ramachandran outliers	187476	6768 (2.20-2.20)
Sidechain outliers	187428	6769 (2.20-2.20)





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	200	
1	B	200	
1	C	200	
1	D	200	
1	E	200	
1	F	200	
2	M	238	
2	N	238	

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Mol	Chain	Length	Quality of chain
2	O	238	 68% 26% . . .
2	P	238	 70% 21% 6% .
2	Q	238	 70% 22% 5% .
2	R	238	 64% 30% . .

2 Entry composition [i](#)

There are 6 unique types of molecules in this entry. The entry contains 22020 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 PROTOCATECHUATE 3,4-DIOXYGENASE.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	200	1571	993	276	299	3	0	0	0
1	B	200	1571	993	276	299	3	0	0	0
1	C	200	1571	993	276	299	3	0	0	0
1	D	200	1571	993	276	299	3	0	0	0
1	E	200	1571	993	276	299	3	0	0	0
1	F	200	1571	993	276	299	3	0	0	0

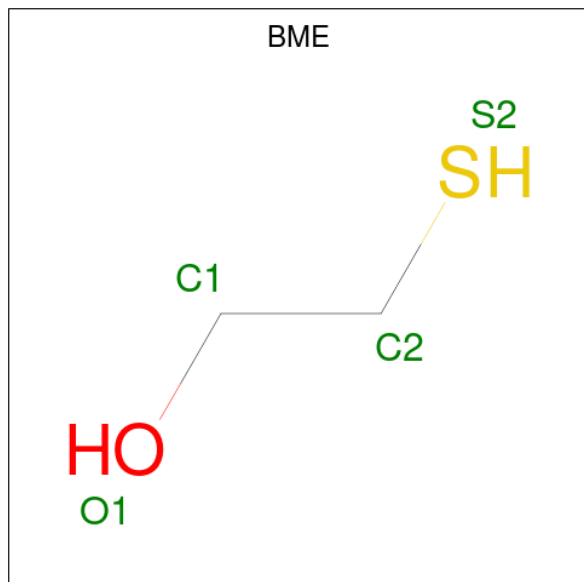
- Molecule 2 is a protein called PROTOCATECHUATE 3,4-DIOXYGENASE.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
2	M	233	1840	1171	334	328	7	0	0	0
2	N	233	1840	1171	334	328	7	0	0	0
2	O	233	1840	1171	334	328	7	0	0	0
2	P	233	1840	1171	334	328	7	0	0	0
2	Q	233	1840	1171	334	328	7	0	0	0
2	R	233	1840	1171	334	328	7	0	0	0

- Molecule 3 is FE (III) ION (CCD ID: FE) (formula: Fe).

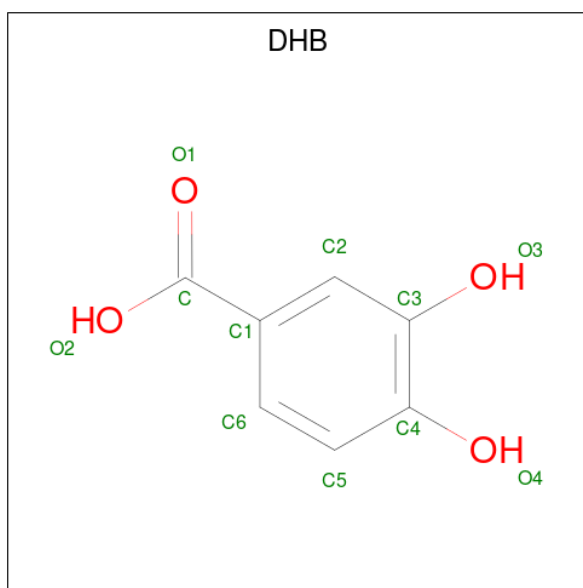
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	M	1	Total Fe 1 1	0	0
3	N	1	Total Fe 1 1	0	0
3	O	1	Total Fe 1 1	0	0
3	P	1	Total Fe 1 1	0	0
3	Q	1	Total Fe 1 1	0	0
3	R	1	Total Fe 1 1	0	0

- Molecule 4 is BETA-MERCAPTOETHANOL (CCD ID: BME) (formula: C₂H₆OS).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	M	1	Total C O S 4 2 1 1	0	0
4	N	1	Total C O S 4 2 1 1	0	0
4	O	1	Total C O S 4 2 1 1	0	0
4	P	1	Total C O S 4 2 1 1	0	0
4	Q	1	Total C O S 4 2 1 1	0	0
4	R	1	Total C O S 4 2 1 1	0	0

- Molecule 5 is 3,4-DIHYDROXYBENZOIC ACID (CCD ID: DHB) (formula: C₇H₆O₄).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
5	M	1	Total C O 11 7 4	0	0
5	M	1	Total C O 11 7 4	0	0
5	N	1	Total C O 11 7 4	0	0
5	N	1	Total C O 11 7 4	0	0
5	N	1	Total C O 11 7 4	0	0
5	O	1	Total C O 11 7 4	0	0
5	P	1	Total C O 11 7 4	0	0
5	P	1	Total C O 11 7 4	0	0
5	Q	1	Total C O 11 7 4	0	0
5	Q	1	Total C O 11 7 4	0	0
5	R	1	Total C O 11 7 4	0	0
5	R	1	Total C O 11 7 4	0	0

- Molecule 6 is water.

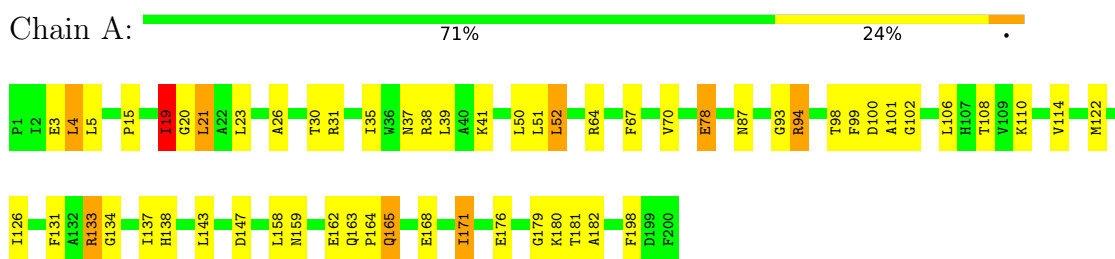
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
6	A	84	Total O 84 84	0	0
6	M	148	Total O 148 148	0	0
6	B	78	Total O 78 78	0	0
6	N	160	Total O 160 160	0	0
6	C	83	Total O 83 83	0	0
6	O	146	Total O 146 146	0	0
6	D	76	Total O 76 76	0	0
6	P	149	Total O 149 149	0	0
6	E	79	Total O 79 79	0	0
6	Q	156	Total O 156 156	0	0
6	F	81	Total O 81 81	0	0
6	R	152	Total O 152 152	0	0

3 Residue-property plots [i](#)

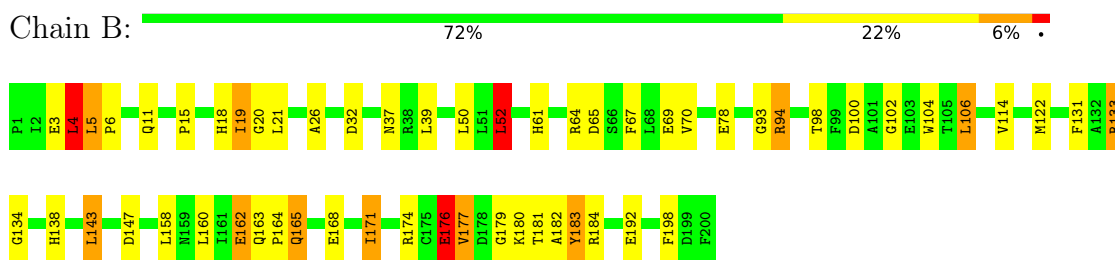
These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry. Residues are color-coded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

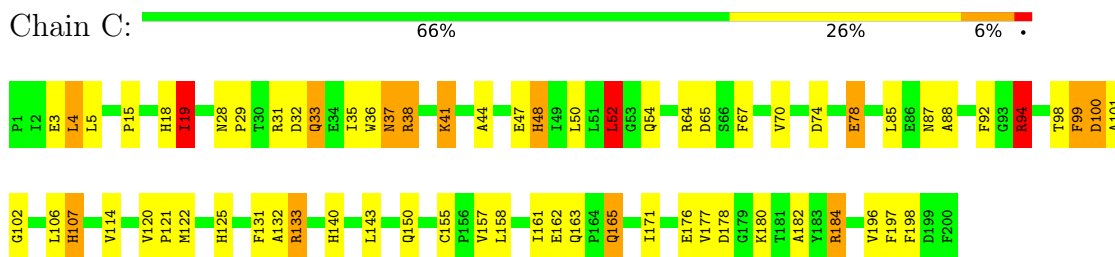
- Molecule 1: PROTOCATECHUATE 3,4-DIOXYGENASE



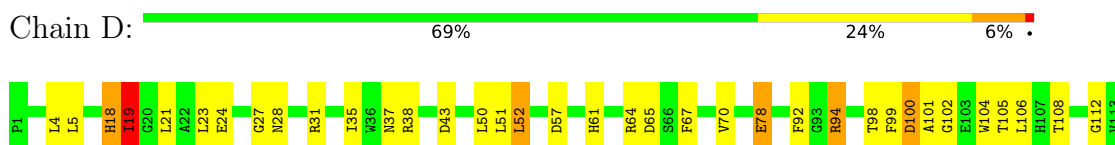
- Molecule 1: PROTOCATECHUATE 3,4-DIOXYGENASE



- Molecule 1: PROTOCATECHUATE 3,4-DIOXYGENASE

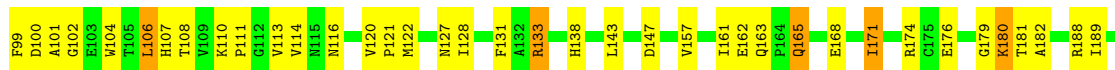
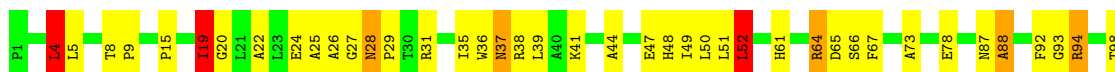


- Molecule 1: PROTOCATECHUATE 3,4-DIOXYGENASE

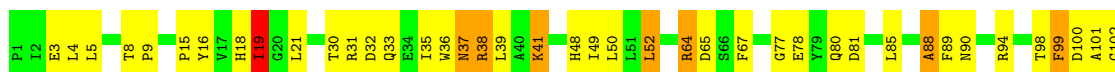




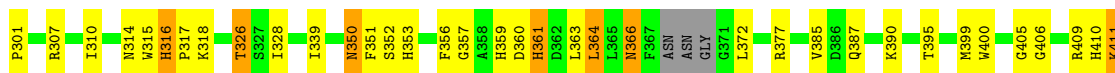
- Molecule 1: PROTOCATECHUATE 3,4-DIOXYGENASE



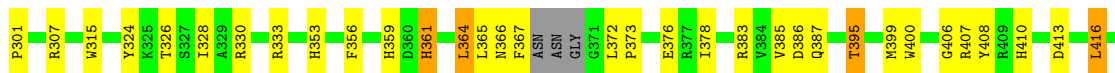
- Molecule 1: PROTOCATECHUATE 3,4-DIOXYGENASE



- Molecule 2: PROTOCATECHUATE 3,4-DIOXYGENASE



- Molecule 2: PROTOCATECHUATE 3,4-DIOXYGENASE



4 Data and refinement statistics

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

Property	Value	Source
Space group	I 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	196.30Å 127.20Å 133.80Å 90.00° 97.60° 90.00°	Depositor
Resolution (Å)	6.00 – 2.20	Depositor
% Data completeness (in resolution range)	96.0 (6.00-2.20)	Depositor
R_{merge}	(Not available)	Depositor
R_{sym}	0.10	Depositor
Refinement program	PROLSQ	Depositor
R, R_{free}	0.165 , (Not available)	Depositor
Estimated twinning fraction	No twinning to report.	Xtrriage
Total number of atoms	22020	wwPDB-VP
Average B, all atoms (Å ²)	21.0	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: BME, DHB, FE

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	1.15	2/1611 (0.1%)	1.75	23/2195 (1.0%)
1	B	1.15	2/1611 (0.1%)	1.72	19/2195 (0.9%)
1	C	1.17	0/1611	1.72	27/2195 (1.2%)
1	D	1.18	2/1611 (0.1%)	1.71	30/2195 (1.4%)
1	E	1.20	1/1611 (0.1%)	1.73	25/2195 (1.1%)
1	F	1.21	2/1611 (0.1%)	1.75	22/2195 (1.0%)
2	M	1.24	2/1895 (0.1%)	1.77	27/2580 (1.0%)
2	N	1.21	2/1895 (0.1%)	1.74	24/2580 (0.9%)
2	O	1.21	2/1895 (0.1%)	1.76	24/2580 (0.9%)
2	P	1.22	1/1895 (0.1%)	1.74	25/2580 (1.0%)
2	Q	1.25	2/1895 (0.1%)	1.74	25/2580 (1.0%)
2	R	1.23	1/1895 (0.1%)	1.75	28/2580 (1.1%)
All	All	1.20	19/21036 (0.1%)	1.74	299/28650 (1.0%)

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	C	0	1

The worst 5 of 19 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	O	451	ASN	CA-C	8.16	1.56	1.52
1	D	94	ARG	CD-NE	-7.71	1.35	1.46
2	N	441	THR	CA-CB	6.77	1.62	1.53
2	Q	441	THR	CA-CB	6.46	1.62	1.54
2	M	451	ASN	CA-C	6.34	1.55	1.52

The worst 5 of 299 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	O	353	HIS	CA-CB-CG	-11.52	102.28	113.80
2	N	522	ARG	CD-NE-CZ	10.79	139.51	124.40
2	Q	452	GLY	N-CA-C	-10.72	99.25	112.23
1	A	94	ARG	CD-NE-CZ	10.24	138.73	124.40
1	D	94	ARG	CD-NE-CZ	10.24	138.73	124.40

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	C	184	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	1571	0	1499	47	0
1	B	1571	0	1499	47	0
1	C	1571	0	1499	53	0
1	D	1571	0	1499	49	0
1	E	1571	0	1499	57	0
1	F	1571	0	1499	67	0
2	M	1840	0	1793	51	0
2	N	1840	0	1793	44	0
2	O	1840	0	1793	51	0
2	P	1840	0	1793	53	0
2	Q	1840	0	1793	54	0
2	R	1840	0	1793	60	0
3	M	1	0	0	0	0
3	N	1	0	0	0	0
3	O	1	0	0	0	0
3	P	1	0	0	0	0
3	Q	1	0	0	0	0
3	R	1	0	0	0	0
4	M	4	0	5	0	0
4	N	4	0	5	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
4	O	4	0	5	0	0
4	P	4	0	5	0	0
4	Q	4	0	5	2	0
4	R	4	0	5	0	0
5	M	22	0	8	1	0
5	N	33	0	13	1	0
5	O	11	0	3	1	0
5	P	22	0	8	0	0
5	Q	22	0	9	0	0
5	R	22	0	9	0	0
6	A	84	0	0	0	0
6	B	78	0	0	0	0
6	C	83	0	0	0	0
6	D	76	0	0	0	0
6	E	79	0	0	1	0
6	F	81	0	0	1	0
6	M	148	0	0	4	0
6	N	160	0	0	1	0
6	O	146	0	0	6	0
6	P	149	0	0	3	0
6	Q	156	0	0	5	0
6	R	152	0	0	5	0
All	All	22020	0	19832	564	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 14.

The worst 5 of 564 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:E:165:GLN:HE21	1:E:165:GLN:N	1.38	1.19
1:E:165:GLN:H	1:E:165:GLN:NE2	1.37	1.19
2:P:364:LEU:HD22	2:P:440:ARG:HD3	1.43	1.00
1:B:165:GLN:H	1:B:165:GLN:NE2	1.61	0.98
1:F:64:ARG:NH1	1:F:100:ASP:O	1.96	0.98

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	198/200 (99%)	192 (97%)	6 (3%)	0	100	100
1	B	198/200 (99%)	192 (97%)	6 (3%)	0	100	100
1	C	198/200 (99%)	193 (98%)	5 (2%)	0	100	100
1	D	198/200 (99%)	189 (96%)	9 (4%)	0	100	100
1	E	198/200 (99%)	189 (96%)	9 (4%)	0	100	100
1	F	198/200 (99%)	190 (96%)	8 (4%)	0	100	100
2	M	229/238 (96%)	222 (97%)	7 (3%)	0	100	100
2	N	229/238 (96%)	221 (96%)	8 (4%)	0	100	100
2	O	229/238 (96%)	222 (97%)	7 (3%)	0	100	100
2	P	229/238 (96%)	223 (97%)	6 (3%)	0	100	100
2	Q	229/238 (96%)	222 (97%)	7 (3%)	0	100	100
2	R	229/238 (96%)	220 (96%)	9 (4%)	0	100	100
All	All	2562/2628 (98%)	2475 (97%)	87 (3%)	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	162/163 (99%)	155 (96%)	7 (4%)	26	35
1	B	162/163 (99%)	153 (94%)	9 (6%)	19	24

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	C	162/163 (99%)	156 (96%)	6 (4%)	30	41
1	D	162/163 (99%)	154 (95%)	8 (5%)	22	29
1	E	162/163 (99%)	155 (96%)	7 (4%)	26	35
1	F	162/163 (99%)	157 (97%)	5 (3%)	35	48
2	M	196/202 (97%)	188 (96%)	8 (4%)	27	37
2	N	196/202 (97%)	187 (95%)	9 (5%)	24	32
2	O	196/202 (97%)	185 (94%)	11 (6%)	19	24
2	P	196/202 (97%)	187 (95%)	9 (5%)	24	32
2	Q	196/202 (97%)	188 (96%)	8 (4%)	27	37
2	R	196/202 (97%)	185 (94%)	11 (6%)	19	24
All	All	2148/2190 (98%)	2050 (95%)	98 (5%)	24	32

5 of 98 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	D	180	LYS
1	E	66	SER
2	P	372	LEU
2	P	497	ASN
2	Q	372	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 53 such sidechains are listed below:

Mol	Chain	Res	Type
2	P	305	ASN
1	E	165	GLN
2	R	422	ASN
2	P	361	HIS
2	P	530	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 24 ligands modelled in this entry, 6 are monoatomic - leaving 18 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
5	DHB	M	551	-	11,11,11	1.19	0	15,15,15	1.44	3 (20%)
5	DHB	R	550	3	11,11,11	1.42	3 (27%)	15,15,15	1.25	2 (13%)
5	DHB	R	551	-	11,11,11	1.22	1 (9%)	15,15,15	1.24	3 (20%)
5	DHB	P	551	-	11,11,11	1.30	1 (9%)	15,15,15	1.34	3 (20%)
5	DHB	N	602	-	11,11,11	1.09	0	15,15,15	1.22	2 (13%)
5	DHB	Q	551	-	11,11,11	1.28	0	15,15,15	1.29	2 (13%)
4	BME	N	601	2	3,3,3	0.19	0	2,2,2	0.25	0
4	BME	M	601	2	3,3,3	0.23	0	2,2,2	0.15	0
5	DHB	M	550	3	11,11,11	1.33	1 (9%)	15,15,15	1.20	2 (13%)
4	BME	R	601	2	3,3,3	0.64	0	2,2,2	0.79	0
4	BME	P	601	2	3,3,3	0.39	0	2,2,2	0.74	0
5	DHB	P	550	3	11,11,11	1.34	1 (9%)	15,15,15	1.31	2 (13%)
4	BME	Q	601	2	3,3,3	0.36	0	2,2,2	0.34	0
5	DHB	Q	550	3	11,11,11	1.45	2 (18%)	15,15,15	1.17	2 (13%)
5	DHB	N	550	3	11,11,11	1.40	3 (27%)	15,15,15	1.36	2 (13%)
5	DHB	N	551	-	11,11,11	1.20	0	15,15,15	1.17	2 (13%)
4	BME	O	601	2	3,3,3	0.47	0	2,2,2	0.34	0
5	DHB	O	550	3	11,11,11	1.56	3 (27%)	15,15,15	1.32	2 (13%)

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
5	DHB	M	551	-	-	0/4/4/4	0/1/1/1
5	DHB	R	550	3	-	0/4/4/4	0/1/1/1
5	DHB	R	551	-	-	0/4/4/4	0/1/1/1
5	DHB	P	551	-	-	0/4/4/4	0/1/1/1
5	DHB	N	602	-	-	0/4/4/4	0/1/1/1
5	DHB	Q	551	-	-	0/4/4/4	0/1/1/1
4	BME	N	601	2	-	0/1/1/1	-
4	BME	M	601	2	-	1/1/1/1	-
5	DHB	M	550	3	-	0/4/4/4	0/1/1/1
4	BME	R	601	2	-	0/1/1/1	-
4	BME	P	601	2	-	0/1/1/1	-
5	DHB	P	550	3	-	0/4/4/4	0/1/1/1
4	BME	Q	601	2	-	0/1/1/1	-
5	DHB	Q	550	3	-	0/4/4/4	0/1/1/1
5	DHB	N	550	3	-	0/4/4/4	0/1/1/1
5	DHB	N	551	-	-	0/4/4/4	0/1/1/1
4	BME	O	601	2	-	0/1/1/1	-
5	DHB	O	550	3	-	0/4/4/4	0/1/1/1

The worst 5 of 15 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
5	P	550	DHB	O4-C4	3.10	1.42	1.36
5	O	550	DHB	C6-C1	2.80	1.43	1.39
5	O	550	DHB	O4-C4	2.69	1.41	1.36
5	Q	550	DHB	C2-C1	2.58	1.43	1.39
5	M	550	DHB	C6-C1	2.41	1.43	1.39

The worst 5 of 27 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
5	N	550	DHB	O2-C-O1	-3.63	115.55	123.35
5	R	550	DHB	O2-C-O1	-3.35	116.15	123.35
5	P	550	DHB	O2-C-O1	-3.19	116.49	123.35
5	O	550	DHB	O2-C-C1	3.08	122.75	114.84
5	M	551	DHB	O2-C-O1	-3.07	116.75	123.35

There are no chirality outliers.

All (1) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
4	M	601	BME	O1-C1-C2-S2

There are no ring outliers.

4 monomers are involved in 5 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
5	M	550	DHB	1	0
4	Q	601	BME	2	0
5	N	550	DHB	1	0
5	O	550	DHB	1	0

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.