



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 6, 2026 – 02:15 PM UTC

PDB ID : 3OPS / pdb_00003ops
Title : Crystal structure of mandelate racemase/muconate lactonizing protein FROM GEOBACILLUS SP. Y412MC10 complexed with magnesium/tartrate
Authors : Malashkevich, V.N.; Patskovsky, Y.; Ramagopal, U.; Toro, R.; Sauder, J.M.; Burley, S.K.; Almo, S.C.; New York SGX Research Center for Structural Genomics (NYSGXRC)
Deposited on : 2010-09-01
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)
Xtriage (Phenix) : 2.0
EDS : 3.0
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4 : 9.0.010 (Gargrove)
Density-Fitness : 1.0.12
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.49

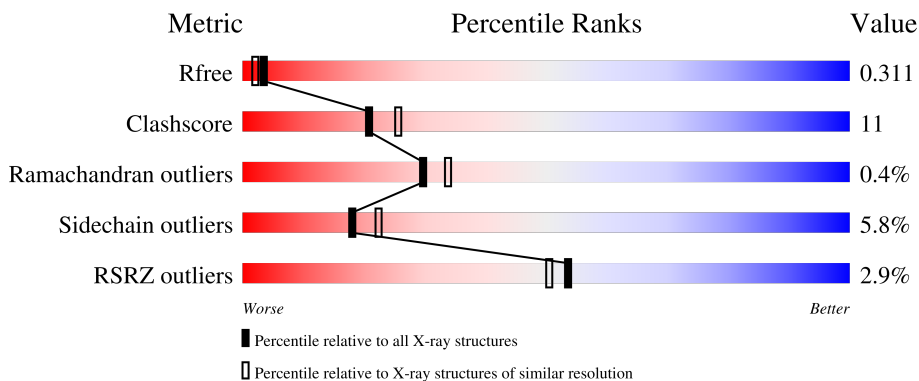
1 Overall quality at a glance

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))
R_{free}	180053	6164 (2.20-2.20)
Clashscore	190562	6851 (2.20-2.20)
Ramachandran outliers	187476	6768 (2.20-2.20)
Sidechain outliers	187428	6769 (2.20-2.20)
RSRZ outliers	180081	6166 (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 $\leq 5\%$. 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.

Mol	Chain	Length	Quality of chain
1	A	392	 73% 24% ..
1	B	392	 72% 23% ..
1	C	392	 79% 18% ..
1	D	392	 66% 26% ..

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
3	TAR	A	503	X	-	-	-
3	TAR	A	504	X	X	-	-
3	TAR	B	503	X	-	X	-
3	TAR	C	503	X	X	-	-
3	TAR	D	503	X	-	-	-

2 Entry composition i

There are 4 unique types of molecules in this entry. The entry contains 13128 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 Mandelate racemase/muconate lactonizing protein.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
			Total	C	N	O	S	Se			
1	A	386	Total 3060	C 1937	N 538	O 575	S 3	Se 7	0	3	0
1	B	386	Total 3050	C 1929	N 536	O 574	S 3	Se 8	0	1	0
1	C	386	Total 3060	C 1939	N 536	O 574	S 3	Se 8	0	3	0
1	D	376	Total 2965	C 1877	N 518	O 560	S 3	Se 7	0	0	0

There are 44 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	1	MSE	-	expression tag	UNP D3EID5
A	2	SER	-	expression tag	UNP D3EID5
A	3	LEU	-	expression tag	UNP D3EID5
A	385	GLU	-	expression tag	UNP D3EID5
A	386	GLY	-	expression tag	UNP D3EID5
A	387	HIS	-	expression tag	UNP D3EID5
A	388	HIS	-	expression tag	UNP D3EID5
A	389	HIS	-	expression tag	UNP D3EID5
A	390	HIS	-	expression tag	UNP D3EID5
A	391	HIS	-	expression tag	UNP D3EID5
A	392	HIS	-	expression tag	UNP D3EID5
B	1	MSE	-	expression tag	UNP D3EID5
B	2	SER	-	expression tag	UNP D3EID5
B	3	LEU	-	expression tag	UNP D3EID5
B	385	GLU	-	expression tag	UNP D3EID5
B	386	GLY	-	expression tag	UNP D3EID5
B	387	HIS	-	expression tag	UNP D3EID5
B	388	HIS	-	expression tag	UNP D3EID5
B	389	HIS	-	expression tag	UNP D3EID5
B	390	HIS	-	expression tag	UNP D3EID5
B	391	HIS	-	expression tag	UNP D3EID5

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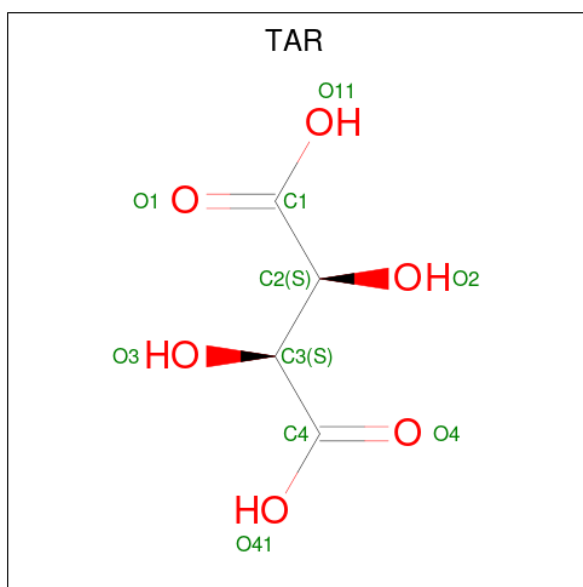
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Chain	Residue	Modelled	Actual	Comment	Reference
B	392	HIS	-	expression tag	UNP D3EID5
C	1	MSE	-	expression tag	UNP D3EID5
C	2	SER	-	expression tag	UNP D3EID5
C	3	LEU	-	expression tag	UNP D3EID5
C	385	GLU	-	expression tag	UNP D3EID5
C	386	GLY	-	expression tag	UNP D3EID5
C	387	HIS	-	expression tag	UNP D3EID5
C	388	HIS	-	expression tag	UNP D3EID5
C	389	HIS	-	expression tag	UNP D3EID5
C	390	HIS	-	expression tag	UNP D3EID5
C	391	HIS	-	expression tag	UNP D3EID5
C	392	HIS	-	expression tag	UNP D3EID5
D	1	MSE	-	expression tag	UNP D3EID5
D	2	SER	-	expression tag	UNP D3EID5
D	3	LEU	-	expression tag	UNP D3EID5
D	385	GLU	-	expression tag	UNP D3EID5
D	386	GLY	-	expression tag	UNP D3EID5
D	387	HIS	-	expression tag	UNP D3EID5
D	388	HIS	-	expression tag	UNP D3EID5
D	389	HIS	-	expression tag	UNP D3EID5
D	390	HIS	-	expression tag	UNP D3EID5
D	391	HIS	-	expression tag	UNP D3EID5
D	392	HIS	-	expression tag	UNP D3EID5

- Molecule 2 is MAGNESIUM ION (CCD ID: MG) (formula: Mg).

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	A	2	Total Mg 2 2	0	0
2	B	2	Total Mg 2 2	0	0
2	C	2	Total Mg 2 2	0	0
2	D	2	Total Mg 2 2	0	0

- Molecule 3 is D(-)-TARTARIC ACID (CCD ID: TAR) (formula: C₄H₆O₆).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	1	Total C O 10 4 6	0	0
3	A	1	Total C O 10 4 6	0	0
3	B	1	Total C O 10 4 6	0	0
3	C	1	Total C O 10 4 6	0	0
3	D	1	Total C O 10 4 6	0	0

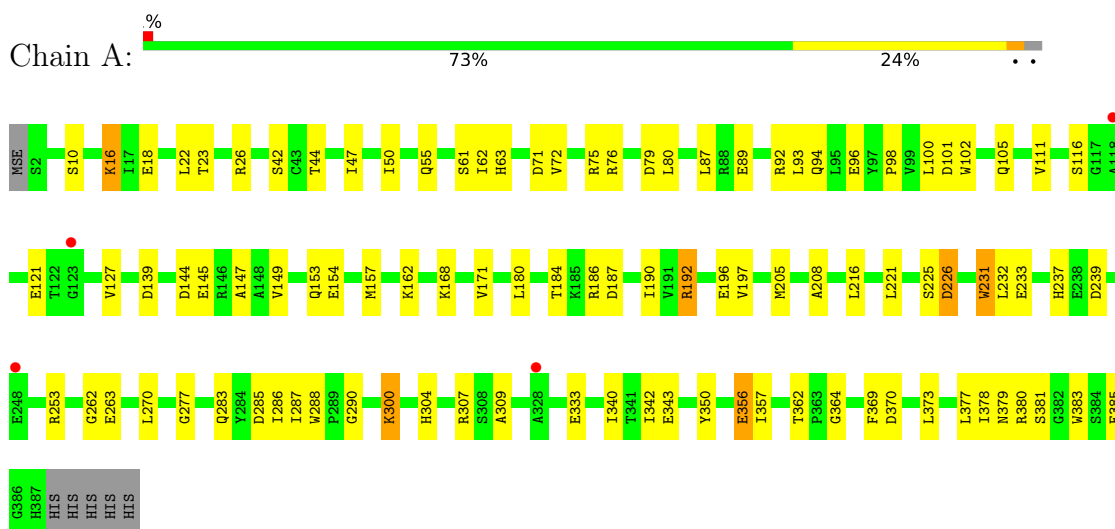
- Molecule 4 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	A	253	Total O 253 253	0	0
4	B	235	Total O 235 235	0	0
4	C	324	Total O 324 324	0	0
4	D	123	Total O 123 123	0	0

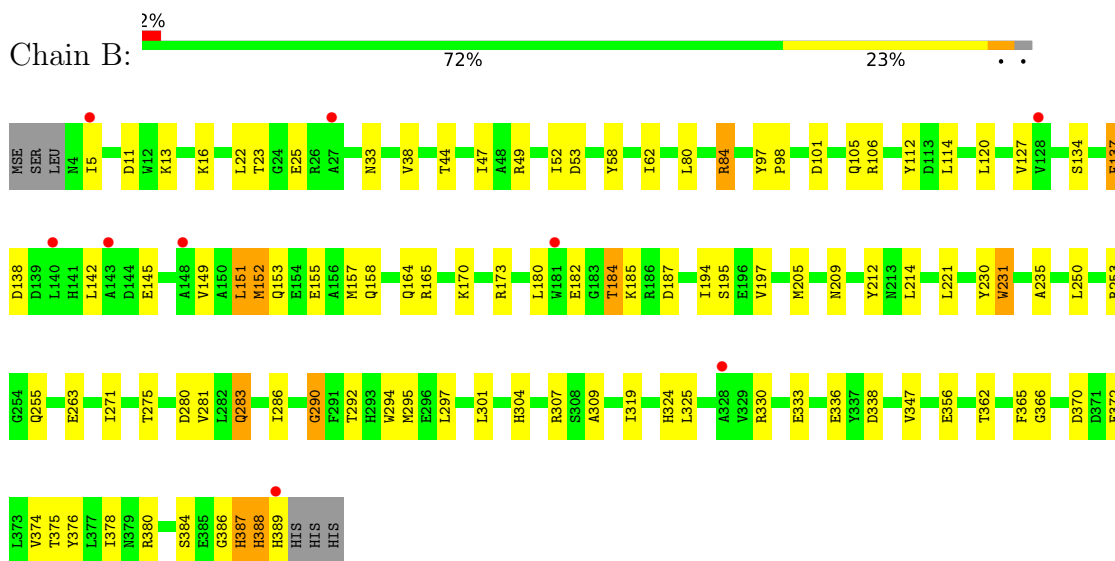
3 Residue-property plots [i](#)

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 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.

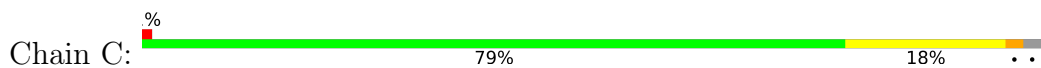
- Molecule 1: Mandelate racemase/muconate lactonizing protein

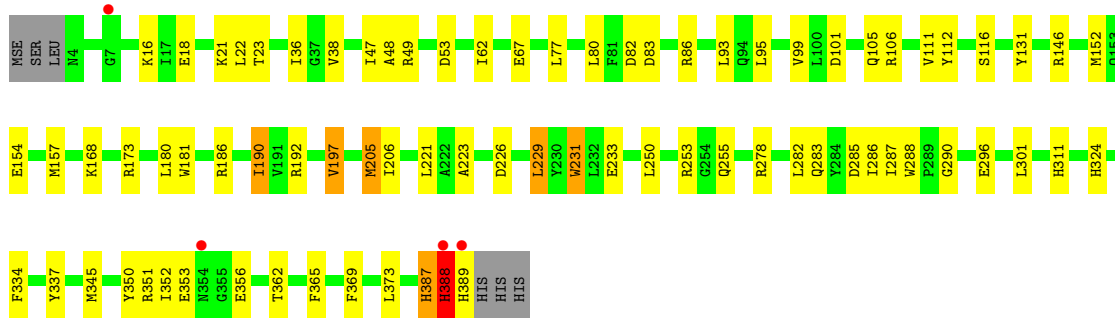


- Molecule 1: Mandelate racemase/muconate lactonizing protein

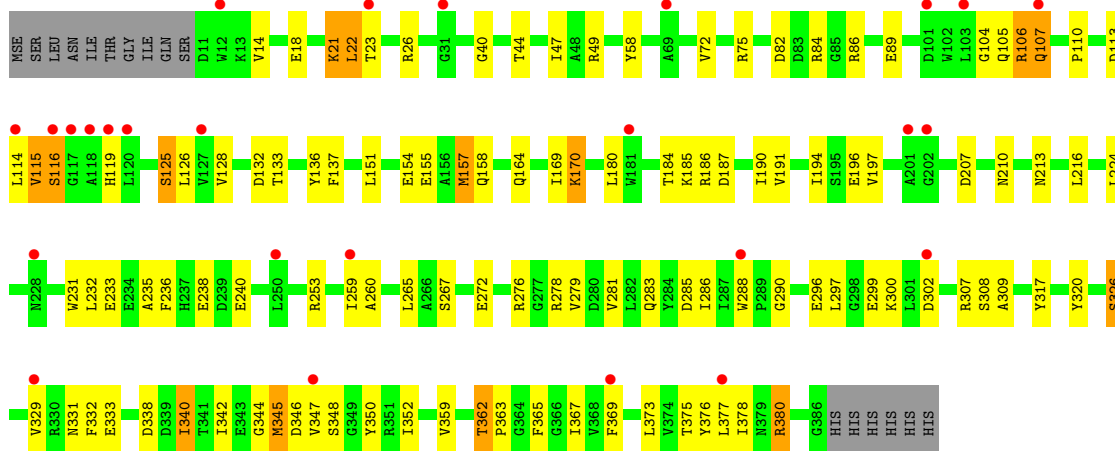


- Molecule 1: Mandelate racemase/muconate lactonizing protein





● Molecule 1: Mandelate racemase/muconate lactonizing protein



4 Data and refinement statistics

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	159.99Å 66.38Å 154.85Å 90.00° 96.59° 90.00°	Depositor
Resolution (Å)	20.00 – 2.20 20.00 – 2.20	Depositor EDS
% Data completeness (in resolution range)	82.5 (20.00-2.20) 82.4 (20.00-2.20)	Depositor EDS
R_{merge}	0.13	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.70 (at 2.19Å)	Xtrriage
Refinement program	REFMAC	Depositor
R, R_{free}	0.228 , 0.311 0.228 , 0.311	Depositor DCC
R_{free} test set	3428 reflections (5.05%)	wwPDB-VP
Wilson B-factor (Å ²)	32.8	Xtrriage
Anisotropy	0.085	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.31 , 44.7	EDS
L-test for twinning ²	$\langle L \rangle = 0.45$, $\langle L^2 \rangle = 0.27$	Xtrriage
Estimated twinning fraction	No twinning to report.	Xtrriage
F_o, F_c correlation	0.93	EDS
Total number of atoms	13128	wwPDB-VP
Average B, all atoms (Å ²)	38.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 57.23 % of the origin peak, indicating pseudo-translational symmetry. The chance of finding a peak of this or larger height randomly in a structure without pseudo-translational symmetry is equal to 2.4399e-05. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

¹Intensities estimated from amplitudes.

²Theoretical values of $\langle |L| \rangle$, $\langle L^2 \rangle$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

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: MG, TAR

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	0.57	0/3133	0.93	2/4234 (0.0%)
1	B	0.59	0/3119	0.93	2/4216 (0.0%)
1	C	0.63	0/3135	0.95	6/4238 (0.1%)
1	D	0.52	0/3028	0.89	1/4093 (0.0%)
All	All	0.58	0/12415	0.92	11/16781 (0.1%)

There are no bond length outliers.

The worst 5 of 11 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	C	362	THR	CA-C-N	6.34	126.36	119.89
1	C	362	THR	C-N-CA	6.34	126.36	119.89
1	C	36	ILE	N-CA-C	6.12	116.29	108.82
1	C	290	GLY	N-CA-C	5.57	118.82	111.70
1	A	383	TRP	N-CA-C	5.39	116.33	108.14

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	3060	0	2967	64	0
1	B	3050	0	2937	73	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	C	3060	0	2959	55	0
1	D	2965	0	2856	74	0
2	A	2	0	0	0	0
2	B	2	0	0	0	0
2	C	2	0	0	0	0
2	D	2	0	0	0	0
3	A	20	0	8	3	0
3	B	10	0	4	7	0
3	C	10	0	3	0	0
3	D	10	0	4	0	0
4	A	253	0	0	14	0
4	B	235	0	0	9	0
4	C	324	0	0	7	0
4	D	123	0	0	6	0
All	All	13128	0	11738	266	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 11.

The worst 5 of 266 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:347:VAL:HG22	4:B:906:HOH:O	1.55	1.05
1:D:132:ASP:HB2	1:D:164:GLN:HG2	1.36	1.02
1:A:237:HIS:HD2	3:A:503:TAR:H2	1.27	0.99
1:B:292:THR:HA	1:B:295:MSE:HE2	1.46	0.98
1:A:237:HIS:CD2	3:A:503:TAR:H2	1.99	0.97

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	387/392 (99%)	372 (96%)	15 (4%)	0	100	100
1	B	385/392 (98%)	361 (94%)	22 (6%)	2 (0%)	24	27
1	C	387/392 (99%)	372 (96%)	14 (4%)	1 (0%)	36	42
1	D	374/392 (95%)	345 (92%)	26 (7%)	3 (1%)	16	16
All	All	1533/1568 (98%)	1450 (95%)	77 (5%)	6 (0%)	30	34

5 of 6 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	C	388	HIS
1	D	115	VAL
1	B	387	HIS
1	B	137	PHE
1	D	116	SER

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	313/308 (102%)	294 (94%)	19 (6%)	17	20
1	B	311/308 (101%)	296 (95%)	15 (5%)	23	30
1	C	313/308 (102%)	301 (96%)	12 (4%)	29	40
1	D	301/308 (98%)	274 (91%)	27 (9%)	9	9
All	All	1238/1232 (100%)	1165 (94%)	73 (6%)	18	22

5 of 73 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	D	157	MSE
1	D	373	LEU
1	D	185	LYS
1	D	300	LYS
1	B	114	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 16 such sidechains are listed below:

Mol	Chain	Res	Type
1	D	283	GLN
1	D	177	HIS
1	C	256	ASN
1	D	158	GLN
1	C	209	ASN

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 13 ligands modelled in this entry, 8 are monoatomic - leaving 5 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	TAR	B	503	2	9,9,9	1.23	0	12,12,12	1.92	4 (33%)
3	TAR	A	503	2	9,9,9	1.10	0	12,12,12	1.44	2 (16%)
3	TAR	C	503	2	9,9,9	1.06	0	12,12,12	1.99	5 (41%)
3	TAR	A	504	2	9,9,9	1.00	0	12,12,12	1.47	3 (25%)
3	TAR	D	503	2	9,9,9	1.17	0	12,12,12	1.30	2 (16%)

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	TAR	B	503	2	1/1/4/4	7/12/12/12	-
3	TAR	A	503	2	1/1/4/4	6/12/12/12	-
3	TAR	C	503	2	1/1/4/4	9/12/12/12	-
3	TAR	A	504	2	1/1/4/4	12/12/12/12	-
3	TAR	D	503	2	1/1/4/4	5/12/12/12	-

There are no bond length outliers.

The worst 5 of 16 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	B	503	TAR	O41-C4-C3	3.38	122.69	113.31
3	C	503	TAR	C2-C3-C4	3.13	116.77	109.82
3	C	503	TAR	O2-C2-C3	3.13	116.53	110.17
3	C	503	TAR	O3-C3-C2	-2.74	104.59	110.17
3	A	503	TAR	C3-C2-C1	2.70	115.80	109.82

All (5) chirality outliers are listed below:

Mol	Chain	Res	Type	Atom
3	A	503	TAR	C2
3	A	504	TAR	C2
3	B	503	TAR	C2
3	C	503	TAR	C2
3	D	503	TAR	C2

5 of 39 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	A	503	TAR	O2-C2-C3-C4
3	A	504	TAR	O11-C1-C2-C3
3	A	504	TAR	C1-C2-C3-O3
3	A	504	TAR	O2-C2-C3-O3
3	B	503	TAR	C2-C3-C4-O4

There are no ring outliers.

2 monomers are involved in 10 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	B	503	TAR	7	0
3	A	503	TAR	3	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](#)

In the following table, the column labelled ‘#RSRZ> 2’ contains the number (and percentage) of RSRZ outliers, followed by percent RSRZ outliers for the chain as percentile scores relative to all X-ray entries and entries of similar resolution. The OWAB column contains the minimum, median, 95th percentile and maximum values of the occupancy-weighted average B-factor per residue. The column labelled ‘Q< 0.9’ lists the number of (and percentage) of residues with an average occupancy less than 0.9.

Mol	Chain	Analysed	<RSRZ>	#RSRZ>2	OWAB(Å ²)	Q<0.9
1	A	379/392 (96%)	0.19	4 (1%) 78 76	20, 36, 59, 68	3 (0%)
1	B	379/392 (96%)	0.35	9 (2%) 59 56	22, 35, 51, 69	0
1	C	379/392 (96%)	0.08	4 (1%) 78 76	10, 29, 43, 68	2 (0%)
1	D	369/392 (94%)	0.78	26 (7%) 22 19	30, 49, 70, 84	0
All	All	1506/1568 (96%)	0.35	43 (2%) 53 50	10, 36, 61, 84	5 (0%)

The worst 5 of 43 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	D	202	GLY	4.0
1	D	120	LEU	3.9
1	D	228	ASN	3.8
1	D	181	TRP	3.5
1	D	347	VAL	3.3

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

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

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled ‘Q< 0.9’ lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(\AA^2)	Q<0.9
3	TAR	A	503	10/10	0.75	0.12	39,41,56,56	0
3	TAR	D	503	10/10	0.85	0.12	47,48,55,55	0
3	TAR	B	503	10/10	0.88	0.10	29,31,37,37	0
2	MG	D	501	1/1	0.89	0.11	59,59,59,59	0
3	TAR	A	504	10/10	0.91	0.11	38,38,40,40	0
3	TAR	C	503	10/10	0.94	0.08	18,20,35,35	0
2	MG	B	500	1/1	0.96	0.04	30,30,30,30	0
2	MG	C	500	1/1	0.96	0.06	21,21,21,21	0
2	MG	C	501	1/1	0.96	0.09	39,39,39,39	0
2	MG	A	501	1/1	0.97	0.04	23,23,23,23	0
2	MG	B	501	1/1	0.97	0.05	26,26,26,26	0
2	MG	A	500	1/1	0.99	0.02	21,21,21,21	0
2	MG	D	500	1/1	0.99	0.02	31,31,31,31	0

6.5 Other polymers [i](#)

There are no such residues in this entry.