



# Full wwPDB X-ray Structure Validation Report ⓘ

Jun 12, 2024 – 09:09 AM EDT

PDB ID : 6NZ9  
Title : Crystal structure of E. coli fumarase C bound to citrate at 1.53 angstrom resolution  
Authors : Stuttgart, G.M.; May, J.F.; Bhattacharyya, B.; Weaver, T.M.  
Deposited on : 2019-02-13  
Resolution : 1.53 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](mailto: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>.

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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) : 1.13  
EDS : 2.36.2  
Percentile statistics : 20191225.v01 (using entries in the PDB archive December 25th 2019)  
Refmac : 5.8.0158  
CCP4 : 7.0.044 (Gargrove)  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)  
Validation Pipeline (wwPDB-VP) : 2.36.2

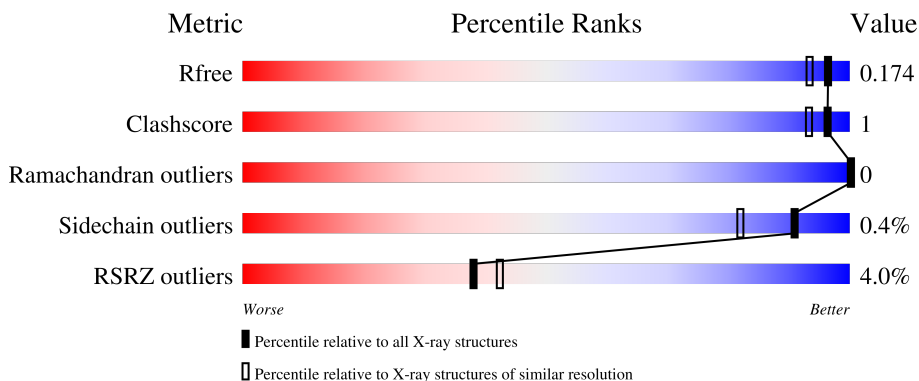
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*X-RAY DIFFRACTION*

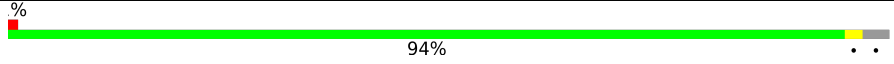
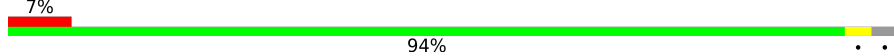
The reported resolution of this entry is 1.53 Å.

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))
$R_{free}$	130704	4009 (1.54-1.50)
Clashscore	141614	4249 (1.54-1.50)
Ramachandran outliers	138981	4148 (1.54-1.50)
Sidechain outliers	138945	4146 (1.54-1.50)
RSRZ outliers	127900	3943 (1.54-1.50)

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  $\geq 3$ , 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	472	 94%
1	B	472	 7% 94%

## 2 Entry composition

There are 3 unique types of molecules in this entry. The entry contains 7813 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 Fumarate hydratase class II.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	456	3503	2187	626	667	23	0	6	0
1	B	459	3524	2201	629	670	24	0	7	0

There are 10 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	468	HIS	-	expression tag	UNP P05042
A	469	HIS	-	expression tag	UNP P05042
A	470	HIS	-	expression tag	UNP P05042
A	471	HIS	-	expression tag	UNP P05042
A	472	HIS	-	expression tag	UNP P05042
B	468	HIS	-	expression tag	UNP P05042
B	469	HIS	-	expression tag	UNP P05042
B	470	HIS	-	expression tag	UNP P05042
B	471	HIS	-	expression tag	UNP P05042
B	472	HIS	-	expression tag	UNP P05042

- Molecule 2 is CITRIC ACID (three-letter code: CIT) (formula: C<sub>6</sub>H<sub>8</sub>O<sub>7</sub>).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	A	1	Total C O 13 6 7	0	0
2	A	1	Total C O 13 6 7	0	0
2	B	1	Total C O 13 6 7	0	0
2	B	1	Total C O 13 6 7	0	0

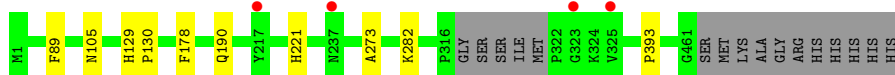
- Molecule 3 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	396	Total O 396 396	0	0
3	B	338	Total O 338 338	0	0

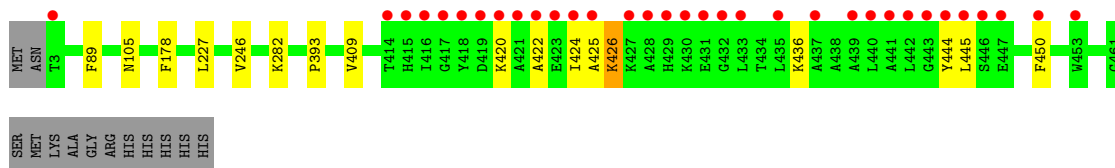
### 3 Residue-property plots

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: Fumarate hydratase class II



- Molecule 1: Fumarate hydratase class II



## 4 Data and refinement statistics

Property	Value	Source
Space group	C 2 2 21	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	103.16Å 216.68Å 86.94Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	45.98 – 1.53 63.55 – 1.53	Depositor EDS
% Data completeness (in resolution range)	100.0 (45.98-1.53) 100.0 (63.55-1.53)	Depositor EDS
$R_{merge}$	0.09	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	2.48 (at 1.52Å)	Xtrriage
Refinement program	PHENIX 1.13_2998	Depositor
R, $R_{free}$	0.157 , 0.173 0.157 , 0.174	Depositor DCC
$R_{free}$ test set	7329 reflections (4.99%)	wwPDB-VP
Wilson B-factor (Å <sup>2</sup> )	16.7	Xtrriage
Anisotropy	0.309	Xtrriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.37 , 45.3	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.50$ , $\langle L^2 \rangle = 0.34$	Xtrriage
Estimated twinning fraction	No twinning to report.	Xtrriage
$F_o, F_c$ correlation	0.97	EDS
Total number of atoms	7813	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	21.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.07% of the height of the origin peak. No significant pseudotranslation is detected.*

<sup>1</sup>Intensities estimated from amplitudes.

<sup>2</sup>Theoretical 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

### 5.1 Standard geometry

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

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	0.33	0/3566	0.53	0/4829
1	B	0.33	0/3591	0.53	0/4862
All	All	0.33	0/7157	0.53	0/9691

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	3503	0	3522	5	0
1	B	3524	0	3551	9	0
2	A	26	0	10	0	0
2	B	26	0	10	0	0
3	A	396	0	0	1	0
3	B	338	0	0	0	0
All	All	7813	0	7093	14	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 1.

All (14) 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:422:ALA:O	1:B:426:LYS:HD3	1.94	0.67
1:A:89:PHE:HA	1:A:105:ASN:HD21	1.60	0.66
1:B:89:PHE:HA	1:B:105:ASN:HD21	1.63	0.62
1:A:190[B]:GLN:NE2	3:A:601:HOH:O	2.33	0.62
1:B:227:LEU:HD23	1:B:246:VAL:HG21	2.00	0.43
1:B:178:PHE:CZ	1:B:393:PRO:HD3	2.53	0.43
1:B:420:LYS:HD3	1:B:444:TYR:CD2	2.54	0.43
1:A:178:PHE:CZ	1:A:393:PRO:HD3	2.54	0.42
1:B:420:LYS:O	1:B:424:ILE:HG13	2.20	0.41
1:B:445:LEU:HD13	1:B:450:PHE:HB2	2.01	0.41
1:A:221:HIS:CD2	1:A:273:ALA:HB2	2.55	0.41
1:B:409:VAL:HG21	1:B:425:ALA:HB2	2.02	0.40
1:A:129:HIS:HA	1:A:130:PRO:HD3	1.97	0.40
1:B:436:LYS:HE3	1:B:450:PHE:CD1	2.56	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	458/472 (97%)	447 (98%)	11 (2%)	0	100	100
1	B	464/472 (98%)	454 (98%)	10 (2%)	0	100	100
All	All	922/944 (98%)	901 (98%)	21 (2%)	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	374/381 (98%)	373 (100%)	1 (0%)	92	84
1	B	377/381 (99%)	375 (100%)	2 (0%)	88	78
All	All	751/762 (99%)	748 (100%)	3 (0%)	91	82

All (3) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	282	LYS
1	B	282	LYS
1	B	426	LYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (6) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	105	ASN
1	A	172	ASN
1	A	188	HIS
1	B	101	GLN
1	B	105	ASN
1	B	188	HIS

### 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 monosaccharides 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	CIT	A	502	-	12,12,12	1.03	0	17,17,17	1.35	1 (5%)
2	CIT	A	501	-	12,12,12	1.06	0	17,17,17	1.53	1 (5%)
2	CIT	B	501	-	12,12,12	1.02	0	17,17,17	1.59	1 (5%)
2	CIT	B	502	-	12,12,12	1.12	0	17,17,17	1.44	1 (5%)

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	CIT	A	502	-	-	0/16/16/16	-
2	CIT	A	501	-	-	4/16/16/16	-
2	CIT	B	501	-	-	0/16/16/16	-
2	CIT	B	502	-	-	5/16/16/16	-

There are no bond length outliers.

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	501	CIT	O6-C6-C3	4.47	120.81	113.05
2	A	501	CIT	O6-C6-C3	4.04	120.07	113.05
2	B	502	CIT	O6-C6-C3	3.68	119.45	113.05
2	A	502	CIT	O6-C6-C3	3.31	118.79	113.05

There are no chirality outliers.

All (9) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	B	502	CIT	C4-C3-C6-O6
2	A	501	CIT	C1-C2-C3-O7
2	A	501	CIT	C2-C3-C6-O6
2	A	501	CIT	C4-C3-C6-O6
2	B	502	CIT	C2-C3-C6-O6
2	B	502	CIT	C4-C3-C6-O5
2	B	502	CIT	C1-C2-C3-O7
2	A	501	CIT	C2-C3-C6-O5
2	B	502	CIT	C2-C3-C6-O5

There are no ring outliers.

No monomer is involved in short contacts.

## 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

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, 95<sup>th</sup> 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 <sup>2</sup> )	Q<0.9
1	A	456/472 (96%)	-0.37	4 (0%) 84 87	12, 17, 29, 58	0
1	B	459/472 (97%)	-0.04	33 (7%) 15 16	12, 18, 56, 72	0
All	All	915/944 (96%)	-0.21	37 (4%) 38 42	12, 18, 44, 72	0

All (37) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	440	LEU	6.9
1	B	433	LEU	6.4
1	B	424	ILE	6.3
1	B	418	TYR	6.1
1	B	444	TYR	5.5
1	B	441	ALA	5.3
1	B	442	LEU	5.2
1	A	325	VAL	5.1
1	B	420	LYS	4.7
1	B	3	THR	4.5
1	B	445	LEU	4.4
1	B	453	TRP	4.4
1	B	439	ALA	4.4
1	A	323	GLY	4.1
1	B	421	ALA	3.9
1	B	443	GLY	3.8
1	B	447	GLU	3.8
1	B	430	LYS	3.7
1	B	437	ALA	3.6
1	B	419	ASP	3.3
1	B	425	ALA	3.3
1	B	415	HIS	2.9
1	B	446	SER	2.9
1	B	450	PHE	2.8

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Mol	Chain	Res	Type	RSRZ
1	B	422	ALA	2.7
1	A	237	ASN	2.6
1	B	423	GLU	2.5
1	B	431	GLU	2.4
1	B	427	LYS	2.4
1	B	428	ALA	2.4
1	B	417	GLY	2.3
1	B	416	ILE	2.2
1	A	217	TYR	2.2
1	B	432	GLY	2.2
1	B	414	THR	2.2
1	B	429	HIS	2.1
1	B	435	LEU	2.0

## 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 monosaccharides 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, 95<sup>th</sup> 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(Å <sup>2</sup> )	Q<0.9
2	CIT	B	502	13/13	0.66	0.27	25,37,41,43	0
2	CIT	B	501	13/13	0.90	0.16	23,27,36,41	0
2	CIT	A	502	13/13	0.91	0.19	22,25,43,49	0
2	CIT	A	501	13/13	0.92	0.13	23,26,31,32	0

## 6.5 Other polymers [i](#)

There are no such residues in this entry.