



# wwPDB X-ray Structure Validation Summary Report ⓘ

Sep 17, 2017 – 08:53 AM EDT

PDB ID : 5UCD  
Title : Benzaldehyde Dehydrogenase, a Class 3 Aldehyde Dehydrogenase, with bound NADP+ and Benzoate Adduct  
Authors : Zahniser, M.P.D.; Prasad, S.; Kneen, M.M.; Kreinbring, C.A.; Petsko, G.A.; Ringe, D.; McLeish, M.J.  
Deposited on : unknown  
Resolution : 2.28 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](mailto: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	:	1.7.2 (RC1), CSD as538be (2017)
Xtriage (Phenix)	:	1.9-1692
EDS	:	rb-20029824
Percentile statistics	:	20161228.v01 (using entries in the PDB archive December 28th 2016)
Refmac	:	5.8.0135
CCP4	:	6.5.0
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	rb-20029824

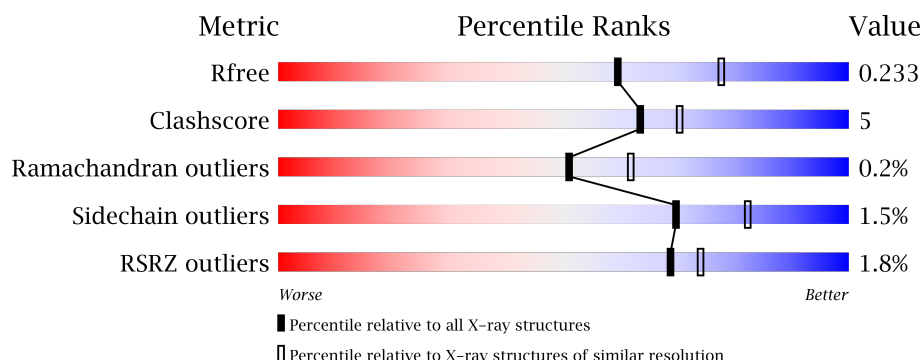
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

## *X-RAY DIFFRACTION*

The reported resolution of this entry is 2.28 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))
$R_{free}$	100719	5609 (2.30-2.26)
Clashscore	112137	6364 (2.30-2.26)
Ramachandran outliers	110173	6281 (2.30-2.26)
Sidechain outliers	110143	6281 (2.30-2.26)
RSRZ outliers	101464	5639 (2.30-2.26)

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  $\geq 3$ , 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.

Mol	Chain	Length	Quality of chain
1	A	457	
1	B	457	

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
1	ZBZ	A	249	-	-	X	-

## 2 Entry composition

There are 3 unique types of molecules in this entry. The entry contains 7017 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 NAD(P)-dependent benzaldehyde dehydrogenase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	435	Total	C	N	O	S	0	0	0
			3346	2157	547	632	10			
1	B	435	Total	C	N	O	S	0	0	0
			3346	2157	547	632	10			

There are 44 discrepancies between the modelled and reference sequences:

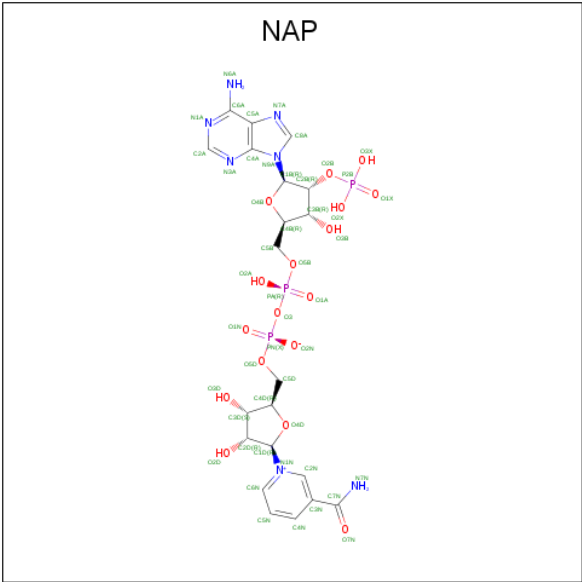
Chain	Residue	Modelled	Actual	Comment	Reference
A	-20	HIS	-	expression tag	UNP Q84DC3
A	-19	HIS	-	expression tag	UNP Q84DC3
A	-18	HIS	-	expression tag	UNP Q84DC3
A	-17	HIS	-	expression tag	UNP Q84DC3
A	-16	HIS	-	expression tag	UNP Q84DC3
A	-15	HIS	-	expression tag	UNP Q84DC3
A	-14	HIS	-	expression tag	UNP Q84DC3
A	-13	HIS	-	expression tag	UNP Q84DC3
A	-12	HIS	-	expression tag	UNP Q84DC3
A	-11	HIS	-	expression tag	UNP Q84DC3
A	-10	SER	-	expression tag	UNP Q84DC3
A	-9	SER	-	expression tag	UNP Q84DC3
A	-8	GLY	-	expression tag	UNP Q84DC3
A	-7	HIS	-	expression tag	UNP Q84DC3
A	-6	ILE	-	expression tag	UNP Q84DC3
A	-5	ASP	-	expression tag	UNP Q84DC3
A	-4	ASP	-	expression tag	UNP Q84DC3
A	-3	ASP	-	expression tag	UNP Q84DC3
A	-2	ASP	-	expression tag	UNP Q84DC3
A	-1	LYS	-	expression tag	UNP Q84DC3
A	0	HIS	-	expression tag	UNP Q84DC3
A	249	ZBZ	CYS	modified residue	UNP Q84DC3
B	-20	HIS	-	expression tag	UNP Q84DC3
B	-19	HIS	-	expression tag	UNP Q84DC3
B	-18	HIS	-	expression tag	UNP Q84DC3

*Continued on next page...*

Continued from previous page...

Chain	Residue	Modelled	Actual	Comment	Reference
B	-17	HIS	-	expression tag	UNP Q84DC3
B	-16	HIS	-	expression tag	UNP Q84DC3
B	-15	HIS	-	expression tag	UNP Q84DC3
B	-14	HIS	-	expression tag	UNP Q84DC3
B	-13	HIS	-	expression tag	UNP Q84DC3
B	-12	HIS	-	expression tag	UNP Q84DC3
B	-11	HIS	-	expression tag	UNP Q84DC3
B	-10	SER	-	expression tag	UNP Q84DC3
B	-9	SER	-	expression tag	UNP Q84DC3
B	-8	GLY	-	expression tag	UNP Q84DC3
B	-7	HIS	-	expression tag	UNP Q84DC3
B	-6	ILE	-	expression tag	UNP Q84DC3
B	-5	ASP	-	expression tag	UNP Q84DC3
B	-4	ASP	-	expression tag	UNP Q84DC3
B	-3	ASP	-	expression tag	UNP Q84DC3
B	-2	ASP	-	expression tag	UNP Q84DC3
B	-1	LYS	-	expression tag	UNP Q84DC3
B	0	HIS	-	expression tag	UNP Q84DC3
B	249	ZBZ	CYS	modified residue	UNP Q84DC3

- Molecule 2 is NADP NICOTINAMIDE-ADENINE-DINUCLEOTIDE PHOSPHATE (three-letter code: NAP) (formula: C<sub>21</sub>H<sub>28</sub>N<sub>7</sub>O<sub>17</sub>P<sub>3</sub>).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	A	1	Total	C	N	O	P	0	0
			48	21	7	17	3		

Continued on next page...

*Continued from previous page...*

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	B	1	Total	C	N	O	P	0	0
			48	21	7	17	3		

- Molecule 3 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	87	Total	O	0	0
			87	87		
3	B	142	Total	O	0	0
			142	142		



- Molecule 1: NAD(P)-dependent benzaldehyde dehydrogenase



## 4 Data and refinement statistics

Property	Value	Source
Space group	I 41 2 2	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	195.00 Å   195.00 Å   129.06 Å 90.00°   90.00°   90.00°	Depositor
Resolution (Å)	34.87 – 2.28 34.86 – 2.28	Depositor EDS
% Data completeness (in resolution range)	99.5 (34.87-2.28) 99.5 (34.86-2.28)	Depositor EDS
$R_{merge}$	0.18	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	2.02 (at 2.27 Å)	Xtriage
Refinement program	PHENIX 1.9_1692	Depositor
R, $R_{free}$	0.190   ,   0.234 0.190   ,   0.233	Depositor DCC
$R_{free}$ test set	2819 reflections (5.01%)	DCC
Wilson B-factor (Å <sup>2</sup> )	34.7	Xtriage
Anisotropy	0.669	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.36 , 31.3	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.50$ , $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
$F_o, F_c$ correlation	0.95	EDS
Total number of atoms	7017	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	29.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.09% 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: NAP, ZBZ

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	0.26	0/3407	0.43	0/4641
1	B	0.27	0/3407	0.43	0/4641
All	All	0.26	0/6814	0.43	0/9282

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	3346	0	3359	47	0
1	B	3346	0	3359	25	0
2	A	48	0	25	20	0
2	B	48	0	24	1	0
3	A	87	0	0	0	0
3	B	142	0	0	1	0
All	All	7017	0	6767	66	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 5.

The worst 5 of 66 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:249:ZBZ:HBA	2:A:501:NAP:C5N	1.69	1.22
1:A:249:ZBZ:HBA	2:A:501:NAP:C6N	1.71	1.21
1:A:249:ZBZ:OAC	2:A:501:NAP:H5N	1.03	1.19
1:A:249:ZBZ:CAM	2:A:501:NAP:H5N	1.71	1.18
1:A:249:ZBZ:SG	2:A:501:NAP:C4N	2.34	1.16

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	432/457 (94%)	415 (96%)	16 (4%)	1 (0%)	51	62
1	B	432/457 (94%)	422 (98%)	9 (2%)	1 (0%)	51	62
All	All	864/914 (94%)	837 (97%)	25 (3%)	2 (0%)	51	62

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	418	HIS
1	A	418	HIS

### 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	365/386 (95%)	358 (98%)	7 (2%)	62	77
1	B	365/386 (95%)	361 (99%)	4 (1%)	78	88
All	All	730/772 (95%)	719 (98%)	11 (2%)	70	82

5 of 11 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	266	LEU
1	A	295	LEU
1	B	300	GLU
1	A	241	LYS
1	B	256	TYR

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. There are no such sidechains identified.

### 5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

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

2 non-standard protein/DNA/RNA residues 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	$\# Z  > 2$
1	ZBZ	A	249	1	14,14,15	1.07	1 (7%)	13,17,19	3.08	2 (15%)
1	ZBZ	B	249	1	14,14,15	1.11	1 (7%)	13,17,19	3.30	2 (15%)

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
1	ZBZ	A	249	1	-	0/9/11/13	0/1/1/1
1	ZBZ	B	249	1	-	0/9/11/13	0/1/1/1

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	B	249	ZBZ	CB-SG	-2.59	1.78	1.81
1	A	249	ZBZ	CB-SG	-2.58	1.78	1.81

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	249	ZBZ	CAN-CAM-SG	2.50	120.20	114.99
1	A	249	ZBZ	CAN-CAM-SG	2.80	120.82	114.99
1	A	249	ZBZ	CB-SG-CAM	10.32	112.70	99.77
1	B	249	ZBZ	CB-SG-CAM	11.26	113.87	99.77

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

1 monomer is involved in 15 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
1	A	249	ZBZ	15	0

## 5.5 Carbohydrates [i](#)

There are no carbohydrates in this entry.

## 5.6 Ligand geometry [i](#)

2 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	NAP	A	501	-	44,52,52	1.20	5 (11%)	51,80,80	1.74	7 (13%)
2	NAP	B	501	-	44,52,52	4.53	15 (34%)	51,80,80	2.29	5 (9%)

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	NAP	A	501	-	-	0/27/67/67	0/5/5/5
2	NAP	B	501	-	-	0/27/67/67	0/5/5/5

The worst 5 of 20 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	B	501	NAP	C2D-C1D	-15.86	1.28	1.53
2	B	501	NAP	O4B-C4B	-5.62	1.32	1.45
2	B	501	NAP	O4D-C4D	-4.55	1.34	1.45
2	B	501	NAP	O3B-C3B	-3.92	1.33	1.43
2	B	501	NAP	O3D-C3D	-2.33	1.37	1.43

The worst 5 of 12 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	501	NAP	N3A-C2A-N1A	-10.02	120.14	128.86
2	B	501	NAP	N6A-C6A-N1A	-7.61	103.67	118.77
2	A	501	NAP	N3A-C2A-N1A	-6.31	123.36	128.86
2	B	501	NAP	C1B-N9A-C4A	-4.50	118.86	126.64
2	A	501	NAP	C4A-C5A-N7A	-4.27	105.29	109.41

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

2 monomers are involved in 21 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	501	NAP	20	0
2	B	501	NAP	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](#)

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	434/457 (94%)	-0.08	15 (3%) 44 50	19, 31, 52, 69	0
1	B	434/457 (94%)	-0.45	1 (0%) 94 96	16, 23, 36, 51	0
All	All	868/914 (94%)	-0.26	16 (1%) 69 74	16, 27, 48, 69	0

The worst 5 of 16 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	312	ALA	4.2
1	A	316	LYS	3.8
1	A	290	ARG	3.0
1	A	125	LEU	2.9
1	A	301	ALA	2.8

### 6.2 Non-standard residues in protein, DNA, RNA chains [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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. 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	LLDF	B-factors(Å <sup>2</sup> )	Q<0.9
1	ZBZ	A	249	14/15	0.87	0.23	-	24,43,51,78	0
1	ZBZ	B	249	14/15	0.87	0.19	-	20,33,43,57	0

### 6.3 Carbohydrates [i](#)

There are no carbohydrates 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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. 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	LLDF	B-factors( $\text{\AA}^2$ )	Q<0.9
2	NAP	A	501	48/48	0.75	0.25	1.81	32,49,62,66	48
2	NAP	B	501	48/48	0.84	0.21	1.46	23,36,49,54	48

## 6.5 Other polymers [i](#)

There are no such residues in this entry.