



# Full wwPDB X-ray Structure Validation Report ⓘ

Nov 13, 2017 – 10:41 AM EST

PDB ID : 4RG3  
Title : Epsilon-caprolactone-bound crystal structure of cyclohexanone monooxygenase in the Tight conformation  
Authors : Yachnin, B.J.; Berghuis, A.M.  
Deposited on : unknown  
Resolution : 1.94 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

<http://wwpdb.org/validation/2016/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

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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 : 1.7.2 (RC1), CSD as538be (2017)  
Xtriage (Phenix) : 1.9-1692  
EDS : rb-20030345  
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-20030345

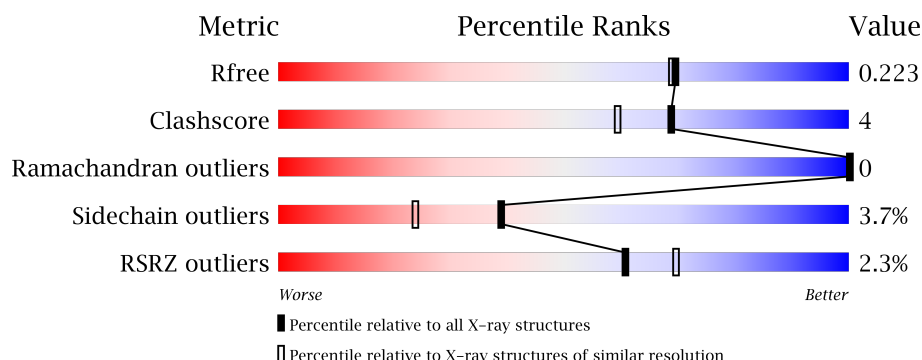
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

## *X-RAY DIFFRACTION*

The reported resolution of this entry is 1.94 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	3233 (1.96-1.92)
Clashscore	112137	3430 (1.96-1.92)
Ramachandran outliers	110173	3395 (1.96-1.92)
Sidechain outliers	110143	3395 (1.96-1.92)
RSRZ outliers	101464	3250 (1.96-1.92)

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	548	<div> <div>2%</div> <div>87%</div> <div>8% . .</div> </div>

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
4	ECE	A	603	-	-	-	X
5	BCN	A	604	-	-	-	X

## 2 Entry composition [i](#)

There are 6 unique types of molecules in this entry. The entry contains 4323 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 Cyclohexanone monooxygenase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	529	4065	2608	692	758	7	0	1	0

There are 8 discrepancies between the modelled and reference sequences:

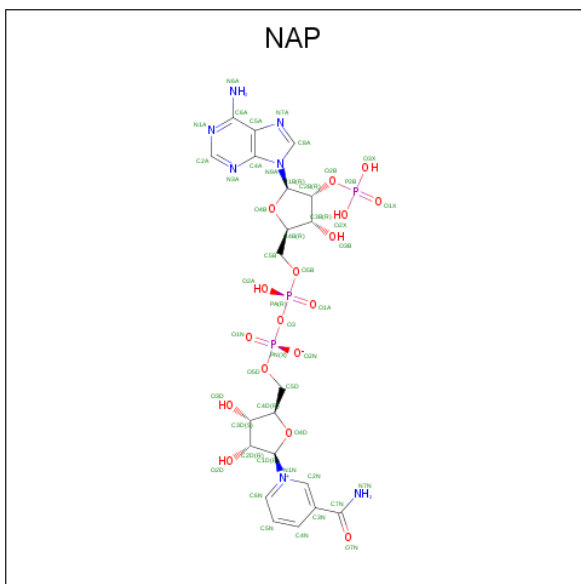
Chain	Residue	Modelled	Actual	Comment	Reference
A	-7	GLY	-	EXPRESSION TAG	UNP C0STX7
A	-6	SER	-	EXPRESSION TAG	UNP C0STX7
A	-5	LEU	-	EXPRESSION TAG	UNP C0STX7
A	-4	GLU	-	EXPRESSION TAG	UNP C0STX7
A	-3	ALA	-	EXPRESSION TAG	UNP C0STX7
A	-2	SER	-	EXPRESSION TAG	UNP C0STX7
A	-1	MET	-	EXPRESSION TAG	UNP C0STX7
A	0	HIS	-	EXPRESSION TAG	UNP C0STX7

- Molecule 2 is FLAVIN-ADENINE DINUCLEOTIDE (three-letter code: FAD) (formula: C<sub>27</sub>H<sub>33</sub>N<sub>9</sub>O<sub>15</sub>P<sub>2</sub>).



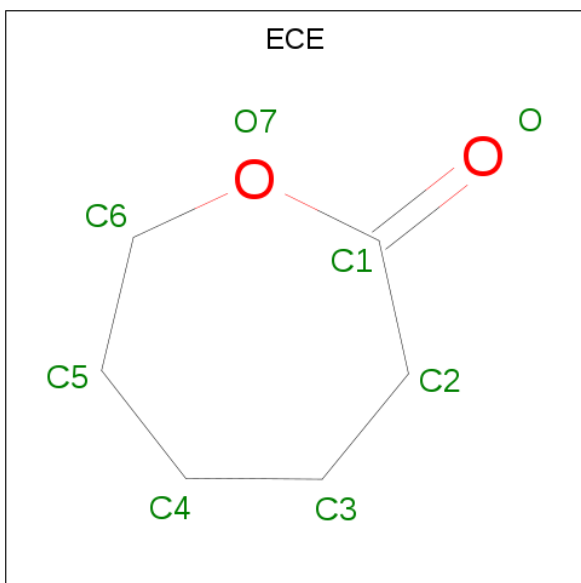
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	A	1	Total	C	N	O	P	0	0
			53	27	9	15	2		

- Molecule 3 is NADP NICOTINAMIDE-ADENINE-DINUCLEOTIDE PHOSPHATE (three-letter code: NAP) (formula:  $\text{C}_{21}\text{H}_{28}\text{N}_7\text{O}_{17}\text{P}_3$ ).



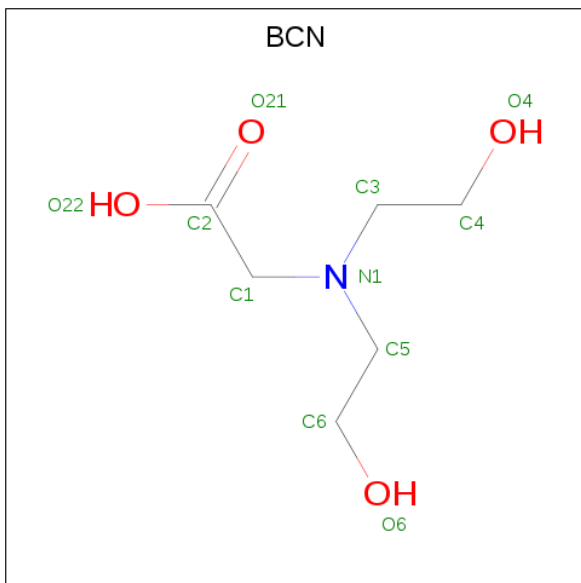
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
3	A	1	Total 48	C 21	N 7	O 17	P 3	0	0

- Molecule 4 is Caprolactone (three-letter code: ECE) (formula:  $\text{C}_6\text{H}_{10}\text{O}_2$ ).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	1	Total	C	O	0	0
			8	6	2		

- Molecule 5 is BICINE (three-letter code: BCN) (formula:  $C_6H_{13}NO_4$ ).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
5	A	1	Total	C	N	O	0	0
			11	6	1	4		

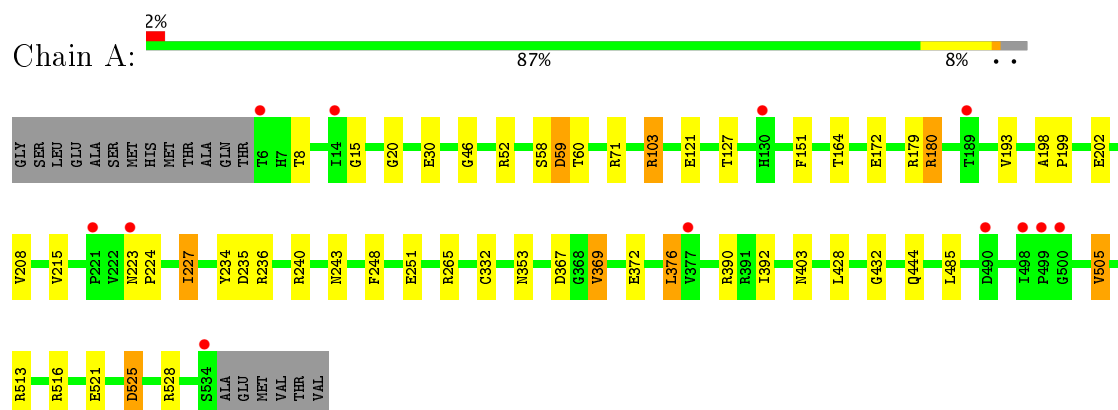
- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	138	Total	O	0	0
			138	138		

### 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 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 ( $\text{RSRZ} > 2$ ). 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: Cyclohexanone monooxygenase



## 4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	55.70 Å 67.06 Å 131.64 Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	24.03 – 1.94 24.03 – 1.94	Depositor EDS
% Data completeness (in resolution range)	97.7 (24.03-1.94) 97.9 (24.03-1.94)	Depositor EDS
$R_{merge}$	0.12	Depositor
$R_{sym}$	0.12	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	2.54 (at 1.95 Å)	Xtriage
Refinement program	REFMAC 5.8.0049	Depositor
R, $R_{free}$	0.165 , 0.218 0.174 , 0.223	Depositor DCC
$R_{free}$ test set	3670 reflections (11.27%)	DCC
Wilson B-factor (Å <sup>2</sup> )	28.1	Xtriage
Anisotropy	0.235	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.37 , 45.4	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.49$ , $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
$F_o, F_c$ correlation	0.96	EDS
Total number of atoms	4323	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	30.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.49% 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: BCN, ECE, NAP, FAD

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	0.87	1/4179 (0.0%)	0.89	8/5707 (0.1%)

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	58	SER	CB-OG	5.34	1.49	1.42

All (8) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	180	ARG	NE-CZ-NH2	6.85	123.72	120.30
1	A	505	VAL	CB-CA-C	-6.60	98.85	111.40
1	A	103	ARG	NE-CZ-NH1	6.52	123.56	120.30
1	A	516	ARG	NE-CZ-NH2	-6.16	117.22	120.30
1	A	265	ARG	NE-CZ-NH2	-5.77	117.41	120.30
1	A	59	ASP	CB-CG-OD1	5.67	123.40	118.30
1	A	103	ARG	NE-CZ-NH2	-5.64	117.48	120.30
1	A	376	LEU	CB-CG-CD2	5.32	120.04	111.00

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	4065	0	3840	32	0
2	A	53	0	31	3	0
3	A	48	0	25	2	0
4	A	8	0	10	0	0
5	A	11	0	12	2	0
6	A	138	0	0	2	0
All	All	4323	0	3918	35	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 4.

All (35) 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)
5:A:604:BCN:H52	5:A:604:BCN:O4	1.62	0.96
1:A:428:LEU:H	1:A:444:GLN:HE22	1.22	0.87
1:A:240:ARG:NH2	1:A:251:GLU:OE1	2.07	0.87
1:A:59:ASP:OD2	1:A:332:CYS:SG	2.39	0.80
1:A:180:ARG:NH2	1:A:372:GLU:O	2.21	0.73
5:A:604:BCN:C5	5:A:604:BCN:O4	2.41	0.68
1:A:223:ASN:O	1:A:227:ILE:HG22	1.94	0.67
2:A:601:FAD:HM73	3:A:602:NAP:C5N	2.30	0.61
1:A:127:THR:HG23	6:A:747:HOH:O	2.02	0.58
1:A:525:ASP:OD2	1:A:528:ARG:NH1	2.36	0.58
1:A:243:ASN:OD1	1:A:513:ARG:NH1	2.40	0.54
1:A:236:ARG:CZ	1:A:240:ARG:HD2	2.40	0.52
1:A:428:LEU:H	1:A:444:GLN:NE2	2.01	0.50
1:A:392:ILE:HD11	2:A:601:FAD:N6A	2.27	0.48
1:A:121:GLU:OE2	1:A:121:GLU:N	2.46	0.48
1:A:353:ASN:HD21	1:A:367:ASP:H	1.63	0.47
1:A:71:ARG:NH2	1:A:235:ASP:OD1	2.49	0.46
1:A:215:VAL:O	1:A:332:CYS:HA	2.16	0.46
1:A:59:ASP:N	3:A:602:NAP:H72N	2.14	0.45
1:A:367:ASP:CG	1:A:369:VAL:HG13	2.37	0.45
1:A:432:GLY:HA3	6:A:704:HOH:O	2.17	0.45
1:A:223:ASN:OD1	1:A:223:ASN:C	2.55	0.44
1:A:392:ILE:HG21	1:A:392:ILE:HD13	1.76	0.44
1:A:390:ARG:HH11	1:A:403:ASN:HD22	1.65	0.44
1:A:46:GLY:HA2	2:A:601:FAD:O3B	2.18	0.43
1:A:15:GLY:O	1:A:20:GLY:HA3	2.19	0.43
1:A:224:PRO:HA	1:A:227:ILE:CG2	2.49	0.43
1:A:198:ALA:N	1:A:199:PRO:CD	2.82	0.42

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:390:ARG:HH11	1:A:403:ASN:ND2	2.18	0.41
1:A:60:THR:HG1	1:A:248:PHE:HE1	1.68	0.41
1:A:227:ILE:HD13	1:A:227:ILE:HG21	1.86	0.41
1:A:179:ARG:HG3	1:A:179:ARG:HH11	1.86	0.41
1:A:52:ARG:NH1	1:A:172:GLU:HG3	2.36	0.40
1:A:223:ASN:O	1:A:227:ILE:CG2	2.66	0.40
1:A:521:GLU:O	1:A:525:ASP:HB2	2.22	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	528/548 (96%)	513 (97%)	15 (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	402/448 (90%)	387 (96%)	15 (4%)	39	24

All (15) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	8	THR
1	A	30	GLU
1	A	103	ARG
1	A	151	PHE
1	A	164	THR
1	A	193	VAL
1	A	202	GLU
1	A	208	VAL
1	A	227	ILE
1	A	234	TYR
1	A	369	VAL
1	A	376	LEU
1	A	485	LEU
1	A	505	VAL
1	A	525	ASP

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (11) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	51	ASN
1	A	150	ASN
1	A	192	GLN
1	A	212	GLN
1	A	270	GLN
1	A	275	HIS
1	A	353	ASN
1	A	403	ASN
1	A	431	ASN
1	A	444	GLN
1	A	482	ASN

### 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	FAD	A	601	-	51,58,58	1.30	7 (13%)	54,89,89	2.09	9 (16%)
3	NAP	A	602	-	44,52,52	1.19	5 (11%)	51,80,80	1.75	8 (15%)
4	ECE	A	603	-	8,8,8	1.47	1 (12%)	9,9,9	3.09	2 (22%)
5	BCN	A	604	-	7,10,10	0.57	0	8,11,11	1.23	1 (12%)

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	FAD	A	601	-	-	0/28/50/50	0/6/6/6
3	NAP	A	602	-	-	0/27/67/67	0/5/5/5
4	ECE	A	603	-	-	0/0/9/9	1/1/1/1
5	BCN	A	604	-	-	0/8/10/10	0/0/0/0

All (13) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	601	FAD	C2-N3	-3.10	1.32	1.38
2	A	601	FAD	C1'-N10	-2.34	1.46	1.48
2	A	601	FAD	C6-C5X	-2.13	1.38	1.41
3	A	602	NAP	P2B-O3X	-2.03	1.46	1.54
3	A	602	NAP	O3D-C3D	2.19	1.48	1.43
3	A	602	NAP	O4B-C1B	2.80	1.45	1.41

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	A	602	NAP	C2A-N3A	2.92	1.37	1.32
2	A	601	FAD	C5A-C4A	2.93	1.47	1.40
2	A	601	FAD	C9A-C5X	2.95	1.48	1.42
4	A	603	ECE	O7-C1	3.00	1.38	1.34
2	A	601	FAD	C4-C4X	3.02	1.47	1.41
3	A	602	NAP	P2B-O2B	3.16	1.65	1.59
2	A	601	FAD	C4X-N5	3.59	1.38	1.33

All (20) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	602	NAP	N3A-C2A-N1A	-7.94	121.94	128.86
4	A	603	ECE	C6-O7-C1	-7.82	108.08	120.96
2	A	601	FAD	C4-C4X-C10	-7.59	113.82	119.96
2	A	601	FAD	N3A-C2A-N1A	-6.67	123.05	128.86
2	A	601	FAD	C4A-C5A-N7A	-2.98	106.53	109.41
2	A	601	FAD	C4B-O4B-C1B	-2.81	106.78	109.77
5	A	604	BCN	C1-N1-C3	-2.64	105.66	111.29
3	A	602	NAP	C3N-C7N-N7N	-2.55	114.86	117.77
2	A	601	FAD	C4X-C10-N10	-2.26	118.95	120.52
3	A	602	NAP	O2D-C2D-C3D	-2.20	104.77	111.83
3	A	602	NAP	O2X-P2B-O2B	-2.03	96.75	106.00
3	A	602	NAP	C4B-O4B-C1B	-2.02	107.62	109.77
3	A	602	NAP	O3X-P2B-O2X	2.13	116.20	107.61
2	A	601	FAD	C4X-N5-C5X	2.34	119.23	116.76
3	A	602	NAP	O3D-C3D-C4D	2.40	118.10	111.09
3	A	602	NAP	O7N-C7N-C3N	4.17	124.50	119.62
2	A	601	FAD	C1'-N10-C9A	4.41	122.39	118.35
4	A	603	ECE	O7-C1-C2	4.57	123.36	119.78
2	A	601	FAD	C4-C4X-N5	4.58	123.70	118.68
2	A	601	FAD	C4-N3-C2	5.62	120.08	115.16

There are no chirality outliers.

There are no torsion outliers.

All (1) ring outliers are listed below:

Mol	Chain	Res	Type	Atoms
4	A	603	ECE	C1-C2-C3-C4-C5-C6-O7

3 monomers are involved in 6 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	601	FAD	3	0
3	A	602	NAP	2	0
5	A	604	BCN	2	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	529/548 (96%)	0.06	12 (2%) 61 70	19, 28, 43, 61	1 (0%)

All (12) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	499	PRO	4.8
1	A	500	GLY	4.2
1	A	490	ASP	3.6
1	A	223	ASN	3.5
1	A	130	HIS	2.8
1	A	534	SER	2.7
1	A	6	THR	2.5
1	A	377	VAL	2.4
1	A	498	ILE	2.4
1	A	221	PRO	2.3
1	A	189	THR	2.1
1	A	14	ILE	2.1

### 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 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(Å <sup>2</sup> )	Q<0.9
4	ECE	A	603	8/8	0.85	0.56	19.82	32,38,39,41	8
5	BCN	A	604	11/11	0.83	0.16	4.02	52,58,63,63	0
2	FAD	A	601	53/53	0.98	0.10	-0.42	20,23,27,33	0
3	NAP	A	602	48/48	0.97	0.09	-0.90	20,24,32,42	0

## 6.5 Other polymers

There are no such residues in this entry.