Full wwPDB X-ray Structure Validation Report (i)

May 29, 2020 – 10:19 am BST

PDB ID	:	5L4S
Title	:	Isopiperitenone reductase from Mentha piperita in complex with NADP and beta-Cyclocitral
Authors	:	Karuppiah, V.; Toogood, H.S.; Leys, D.; Scrutton, N.S.
Deposited on	:	2016-05-26
Resolution	:	1.41 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*
A user guide is available at
https://www.wwpdb.org/validation/2017/XrayValidationReportHelp
with specific help available everywhere you see the (i) symbol.

The following versions of software and data (see references (i)) were used in the production of this report:

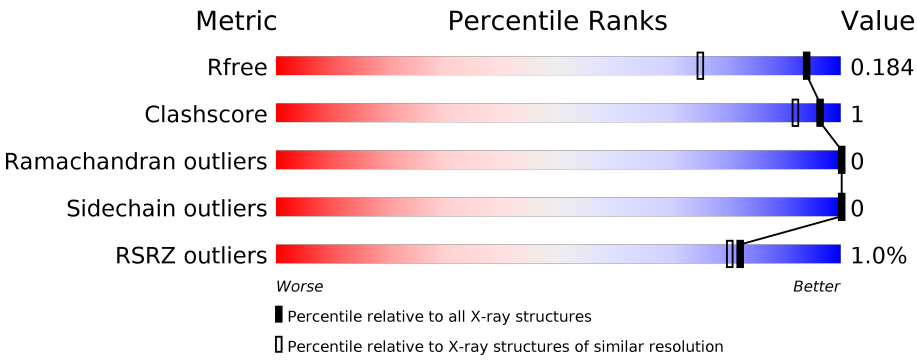
MolProbity	:	4.02b-467
Mogul	:	1.8.5 (274361), CSD as541be (2020)
Xtriage (Phenix)	:	1.13
EDS	:	2.11
buster-report	:	1.1.7 (2018)
Percentile statistics	:	20191225.v01 (using entries in the PDB archive December 25th 2019)
Refmac	:	5.8.0158
CCP4	:	7.0.044 (Gargrove)
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.11

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

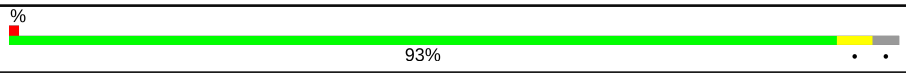
The reported resolution of this entry is 1.41 Å.

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	2579 (1.44-1.40)
Clashscore	141614	2696 (1.44-1.40)
Ramachandran outliers	138981	2632 (1.44-1.40)
Sidechain outliers	138945	2631 (1.44-1.40)
RSRZ outliers	127900	2528 (1.44-1.40)

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 >=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 <=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	318	

2 Entry composition (i)

There are 4 unique types of molecules in this entry. The entry contains 5251 atoms, of which 2486 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.

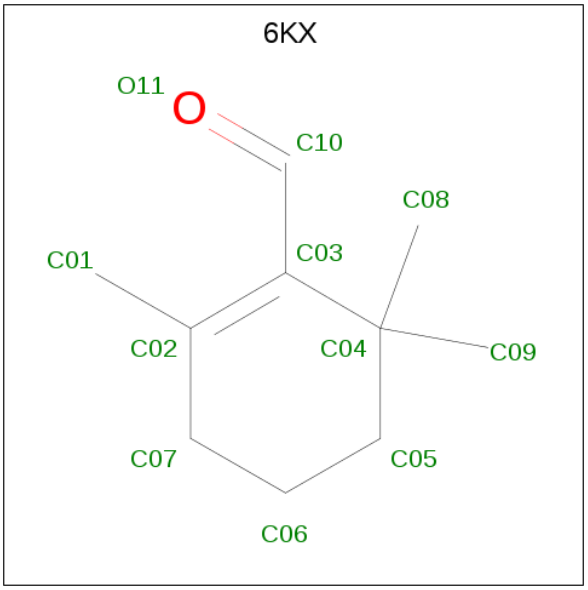
- Molecule 1 is a protein called (-)-isopiperitenone reductase.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
			Total	C	H	N	O	S			
1	A	310	4867	1548	2461	407	445	6	0	2	0

There are 4 discrepancies between the modelled and reference sequences:

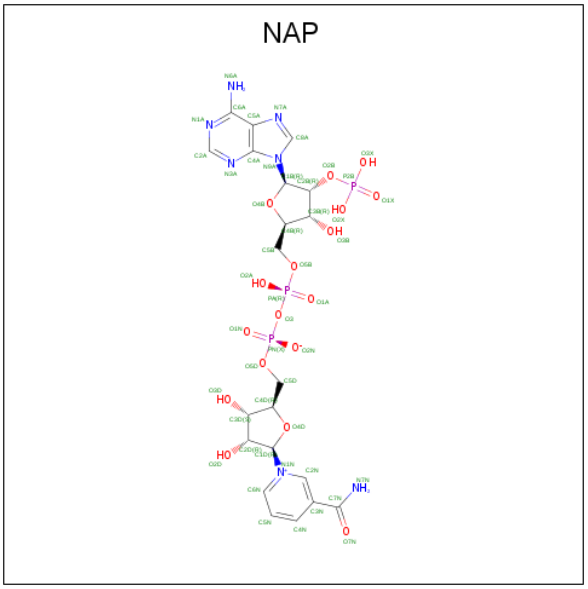
Chain	Residue	Modelled	Actual	Comment	Reference
A	-1	GLY	-	expression tag	UNP Q6WAU1
A	0	ALA	-	expression tag	UNP Q6WAU1
A	315	LEU	-	expression tag	UNP Q6WAU1
A	316	GLU	-	expression tag	UNP Q6WAU1

- Molecule 2 is beta-cyclocitral (three-letter code: 6KX) (formula: $C_{10}H_{16}O$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
			Total	C	O		
2	A	1	11	10	1	0	0

- Molecule 3 is NADP NICOTINAMIDE-ADENINE-DINUCLEOTIDE PHOSPHATE (three-letter code: NAP) (formula: $C_{21}H_{28}N_7O_{17}P_3$).



Mol	Chain	Residues	Atoms						ZeroOcc	AltConf
			Total	C	H	N	O	P		
3	A	1	73	21	25	7	17	3	0	0

- Molecule 4 is water.

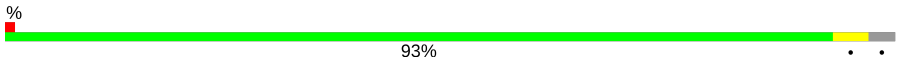
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
			Total	O		
4	A	300	300	300	0	0

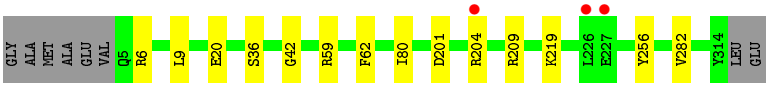
3 Residue-property plots (i)

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 (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: (-)-isopiperitenone reductase

Chain A:





4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α, β, γ	60.11Å 65.61Å 94.81Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	50.77 – 1.41 50.77 – 1.41	Depositor EDS
% Data completeness (in resolution range)	99.5 (50.77-1.41) 99.5 (50.77-1.41)	Depositor EDS
R_{merge}	0.07	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	1.49 (at 1.41Å)	Xtriage
Refinement program	PHENIX (dev_2294: ???)	Depositor
R, R_{free}	0.153 , 0.183 0.154 , 0.184	Depositor DCC
R_{free} test set	3587 reflections (4.94%)	wwPDB-VP
Wilson B-factor (Å^2)	13.9	Xtriage
Anisotropy	0.197	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.41 , 45.1	EDS
L-test for twinning[2]	$< \|L\| > = 0.50$, $< L^2 > = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o,F_c correlation	0.97	EDS
Total number of atoms	5251	wwPDB-VP
Average B, all atoms (Å^2)	19.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.52% of the height of the origin peak. No significant pseudotranslation is detected.*

[1] Intensities estimated from amplitudes.

[2] Theoretical values of $< |L| >$, $< L^2 >$ 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: 6KX, NAP

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	0.72	2/2459 (0.1%)	0.79	4/3328 (0.1%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	256	TYR	CD1-CE1	-5.75	1.30	1.39
1	A	36	SER	CB-OG	-5.67	1.34	1.42

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	A	209	ARG	NE-CZ-NH2	-5.87	117.37	120.30
1	A	6	ARG	NE-CZ-NH2	-5.56	117.52	120.30
1	A	59	ARG	NE-CZ-NH1	5.30	122.95	120.30
1	A	6	ARG	NE-CZ-NH1	5.15	122.87	120.30

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	2406	2461	2464	5	0
2	A	11	0	0	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
3	A	48	25	25	0	0
4	A	300	0	0	0	0
All	All	2765	2486	2489	5	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 (5) 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:20:GLU:HG3	1:A:282[A]:VAL:HG13	1.92	0.50
1:A:201:ASP:OD2	1:A:204:ARG:HD2	2.11	0.49
1:A:42:GLY:HA3	1:A:62:PHE:CE1	2.51	0.45
1:A:9:LEU:HD12	1:A:80:ILE:HD11	1.98	0.44
1:A:219:LYS:HE2	1:A:219:LYS:HB3	1.92	0.41

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	310/318 (98%)	305 (98%)	5 (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	256/259 (99%)	256 (100%)	0	100 100

There are no protein residues with a non-rotameric sidechain to report.

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

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 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	$\#\|Z\| > 2$
3	NAP	A	402	-	45,52,52	2.58	14 (31%)	56,80,80	2.14	17 (30%)
2	6KX	A	401	-	10,11,11	5.26	7 (70%)	14,16,16	2.53	5 (35%)

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	NAP	A	402	-	-	7/31/67/67	0/5/5/5
2	6KX	A	401	-	-	2/2/19/19	0/1/1/1

All (21) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	401	6KX	C02-C03	12.91	1.56	1.34
3	A	402	NAP	O4B-C1B	7.19	1.51	1.41
3	A	402	NAP	C3B-C4B	-5.82	1.38	1.53
3	A	402	NAP	C3D-C4D	-5.40	1.39	1.53
2	A	401	6KX	C05-C06	-5.23	1.39	1.52
2	A	401	6KX	C04-C03	-5.14	1.46	1.53
2	A	401	6KX	C05-C04	4.87	1.65	1.54
3	A	402	NAP	C7N-N7N	4.76	1.42	1.33
3	A	402	NAP	P2B-O2B	4.24	1.67	1.59
3	A	402	NAP	O4B-C4B	3.94	1.53	1.45
2	A	401	6KX	C06-C07	3.86	1.64	1.52
3	A	402	NAP	O4D-C4D	3.74	1.53	1.45
3	A	402	NAP	C5A-C4A	-3.54	1.31	1.40
3	A	402	NAP	C2D-C1D	-3.34	1.48	1.53
3	A	402	NAP	O7N-C7N	-3.33	1.17	1.24
3	A	402	NAP	O3D-C3D	3.03	1.50	1.43
2	A	401	6KX	O11-C10	2.64	1.28	1.22
3	A	402	NAP	P2B-O2X	-2.59	1.44	1.54
3	A	402	NAP	PA-O1A	-2.55	1.41	1.50
2	A	401	6KX	C07-C02	-2.35	1.46	1.51
3	A	402	NAP	C2A-N3A	2.15	1.35	1.32

All (22) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
3	A	402	NAP	C5A-C6A-N6A	7.71	132.06	120.35
2	A	401	6KX	C01-C02-C03	-7.15	116.50	124.53
3	A	402	NAP	C1B-N9A-C4A	-5.22	117.47	126.64
3	A	402	NAP	N6A-C6A-N1A	-5.04	108.11	118.57
3	A	402	NAP	C4A-C5A-N7A	3.72	113.27	109.40
3	A	402	NAP	O7N-C7N-C3N	3.66	124.01	119.63
2	A	401	6KX	C04-C03-C02	-3.45	117.75	122.61
3	A	402	NAP	C2N-C3N-C4N	3.43	122.15	118.26
3	A	402	NAP	O4B-C1B-C2B	-3.08	101.24	106.59

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
3	A	402	NAP	C4N-C3N-C7N	-3.00	113.00	121.04
3	A	402	NAP	C6N-N1N-C2N	-2.92	119.31	121.97
2	A	401	6KX	C01-C02-C07	2.89	119.16	113.62
3	A	402	NAP	C3D-C2D-C1D	-2.74	96.85	100.98
3	A	402	NAP	O7N-C7N-N7N	-2.58	118.92	122.58
3	A	402	NAP	O4B-C4B-C5B	-2.52	101.09	109.37
2	A	401	6KX	C08-C04-C03	2.45	114.28	110.30
3	A	402	NAP	C2D-C3D-C4D	2.42	107.35	102.64
3	A	402	NAP	O2A-PA-O1A	2.29	123.55	112.24
3	A	402	NAP	C2A-N1A-C6A	-2.19	115.01	118.75
2	A	401	6KX	C06-C07-C02	-2.18	110.19	114.08
3	A	402	NAP	C5N-C4N-C3N	-2.17	117.77	120.34
3	A	402	NAP	O2B-P2B-O1X	-2.08	101.37	109.39

There are no chirality outliers.

All (9) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	A	402	NAP	PN-O3-PA-O5B
3	A	402	NAP	C2B-O2B-P2B-O1X
3	A	402	NAP	C5D-O5D-PN-O3
2	A	401	6KX	C02-C03-C10-O11
2	A	401	6KX	C04-C03-C10-O11
3	A	402	NAP	C5D-O5D-PN-O1N
3	A	402	NAP	PA-O3-PN-O1N
3	A	402	NAP	PA-O3-PN-O2N
3	A	402	NAP	O4B-C4B-C5B-O5B

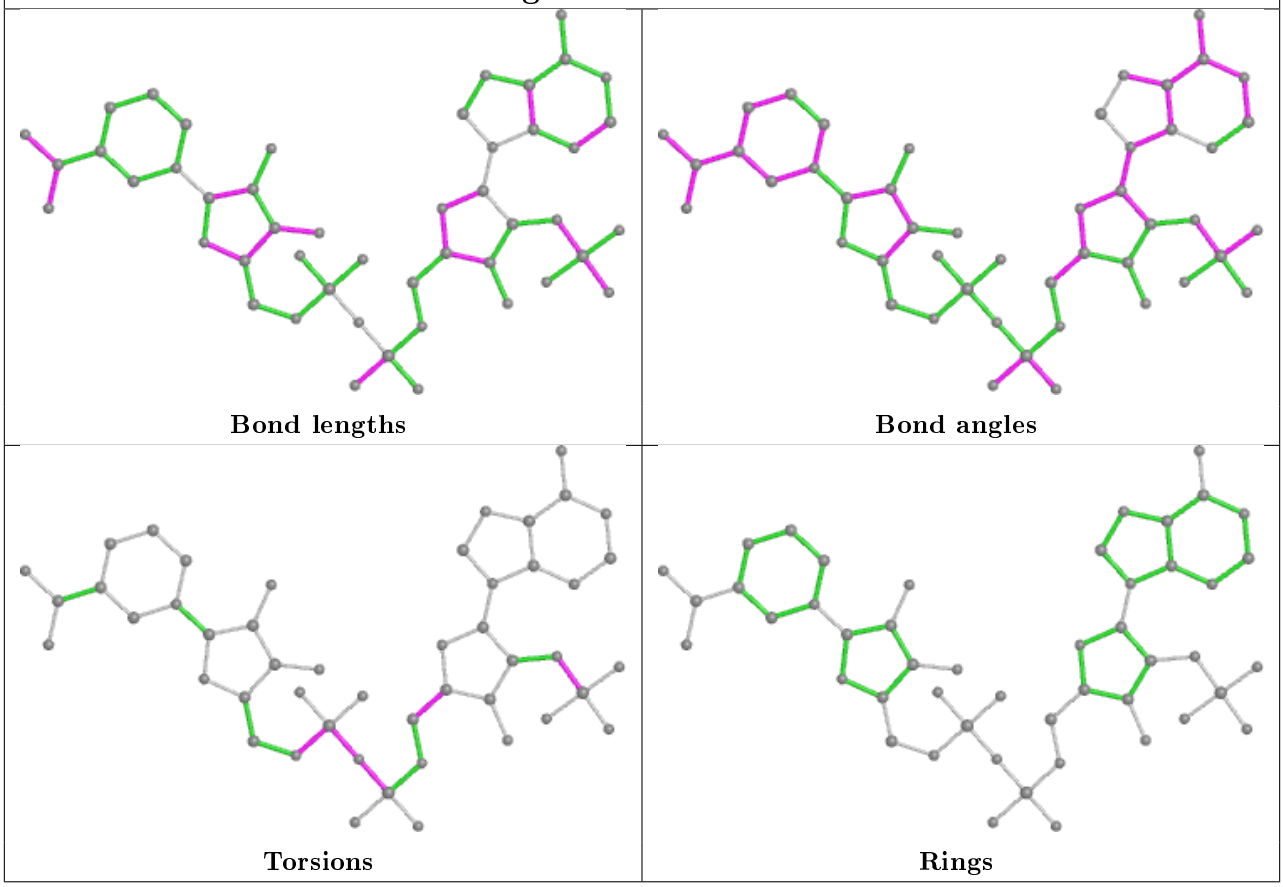
There are no ring outliers.

No monomer is involved in short contacts.

The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less then 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient

equivalents in the CSD to analyse the geometry.

Ligand NAP A 402



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	310/318 (97%)	-0.47	3 (0%) 82 80	10, 15, 28, 43	0

All (3) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	227	GLU	2.4
1	A	226	LEU	2.1
1	A	204	ARG	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 carbohydrates in this entry.

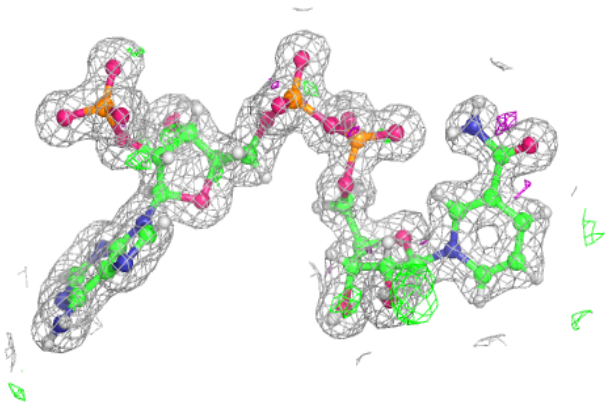
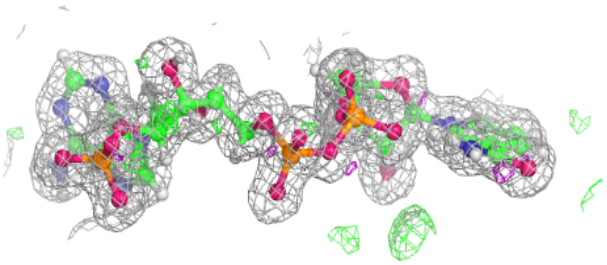
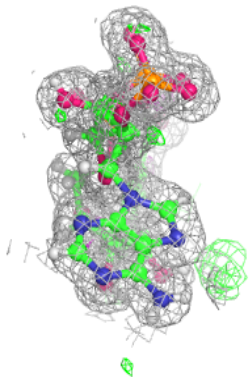
6.4 Ligands (i)

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. 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(Å^2)	Q<0.9
2	6KX	A	401	11/11	0.91	0.09	16,17,19,20	0
3	NAP	A	402	48/48	0.98	0.07	10,12,15,17	0

The following is a graphical depiction of the model fit to experimental electron density of all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers

as shown on the geometry validation Tables will also be included. Each fit is shown from different orientation to approximate a three-dimensional view.

Electron density around NAP A 402: 2mF$_o$-DF$_c$ (at 0.7 rmsd) in gray mF$_o$-DF$_c$ (at 3 rmsd) in purple (negative) and green (positive)	
	

6.5 Other polymers (i)

There are no such residues in this entry.