Full wwPDB X-ray Structure Validation Report ⓘ

May 15, 2025 – 02:52 PM EDT

PDB ID	:	8CV9 / pdb_00008cv9
Title	:	Structure of Hyoscyamine 6-beta Hydroxylase in complex with vanadyl, succinate, and hyoscyamine
Authors	:	Wenger, E.S.; Boal, A.K.; Bollinger, J.M.; Krebs, C.
Deposited on	:	2022-05-18
Resolution	:	1.79 Å(reported)

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

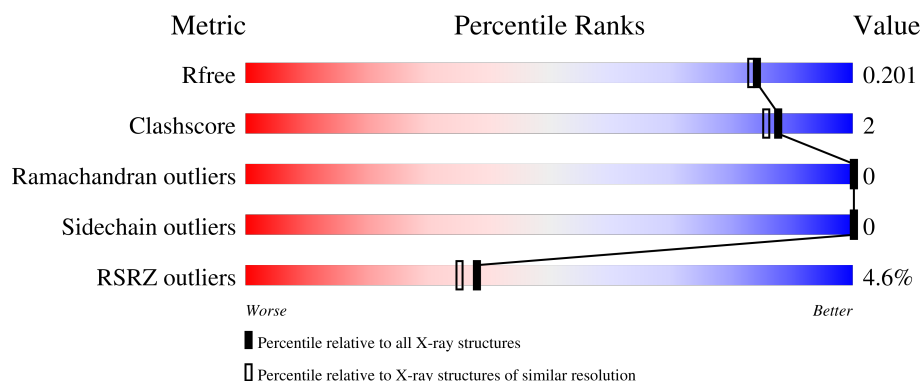|		
MolProbity	:	4-5-2 with Phenix2.0rc1
Mogul	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	2.0rc1
EDS	:	3.0
buster-report	:	1.1.7 (2018)
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.006 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.43.1

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 1.79 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	Percentile Ranks	Value
Rfree		0.201
Clashscore		2
Ramachandran outliers		0
Sidechain outliers		0
RSRZ outliers		4.6%

Worse   *Better*

▮ Percentile relative to all X-ray structures

▯ Percentile relative to X-ray structures of similar resolution

Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	164625	7108 (1.80-1.80)
Clashscore	180529	8162 (1.80-1.80)
Ramachandran outliers	177936	8077 (1.80-1.80)
Sidechain outliers	177891	8076 (1.80-1.80)
RSRZ outliers	164620	7108 (1.80-1.80)

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 <=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	385	4% ... 81% · 15%

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
5	FMT	A	407	-	-	X	X

2   Entry composition ⓘ

There are 9 unique types of molecules in this entry. The entry contains 2942 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 Hyoscyamine 6-beta-hydroxylase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	326	2587	1665	414	497	11	0	0	0

There are 42 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	344	GLY	-	expression tag	UNP Q9XJ43
A	345	GLY	-	expression tag	UNP Q9XJ43
A	346	LYS	-	expression tag	UNP Q9XJ43
A	347	GLY	-	expression tag	UNP Q9XJ43
A	348	PRO	-	expression tag	UNP Q9XJ43
A	349	GLY	-	expression tag	UNP Q9XJ43
A	350	ASP	-	expression tag	UNP Q9XJ43
A	351	GLY	-	expression tag	UNP Q9XJ43
A	352	PRO	-	expression tag	UNP Q9XJ43
A	353	GLY	-	expression tag	UNP Q9XJ43
A	354	GLY	-	expression tag	UNP Q9XJ43
A	355	SER	-	expression tag	UNP Q9XJ43
A	356	GLY	-	expression tag	UNP Q9XJ43
A	357	GLY	-	expression tag	UNP Q9XJ43
A	358	PRO	-	expression tag	UNP Q9XJ43
A	359	ARG	-	expression tag	UNP Q9XJ43
A	360	GLY	-	expression tag	UNP Q9XJ43
A	361	GLY	-	expression tag	UNP Q9XJ43
A	362	GLU	-	expression tag	UNP Q9XJ43
A	363	ASN	-	expression tag	UNP Q9XJ43
A	364	LEU	-	expression tag	UNP Q9XJ43
A	365	TYR	-	expression tag	UNP Q9XJ43
A	366	PHE	-	expression tag	UNP Q9XJ43
A	367	GLN	-	expression tag	UNP Q9XJ43
A	368	SER	-	expression tag	UNP Q9XJ43
A	369	GLY	-	expression tag	UNP Q9XJ43
A	370	HIS	-	expression tag	UNP Q9XJ43

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Chain	Residue	Modelled	Actual	Comment	Reference
A	371	HIS	-	expression tag	UNP Q9XJ43
A	372	HIS	-	expression tag	UNP Q9XJ43
A	373	HIS	-	expression tag	UNP Q9XJ43
A	374	HIS	-	expression tag	UNP Q9XJ43
A	375	HIS	-	expression tag	UNP Q9XJ43
A	376	HIS	-	expression tag	UNP Q9XJ43
A	377	HIS	-	expression tag	UNP Q9XJ43
A	378	GLY	-	expression tag	UNP Q9XJ43
A	379	GLY	-	expression tag	UNP Q9XJ43
A	380	ARG	-	expression tag	UNP Q9XJ43
A	381	GLY	-	expression tag	UNP Q9XJ43
A	382	GLY	-	expression tag	UNP Q9XJ43
A	383	ALA	-	expression tag	UNP Q9XJ43
A	384	ALA	-	expression tag	UNP Q9XJ43
A	385	ALA	-	expression tag	UNP Q9XJ43

- Molecule 2 is 1,2-ETHANEDIOL (CCD ID: EDO) (formula: $C_2H_6O_2$).

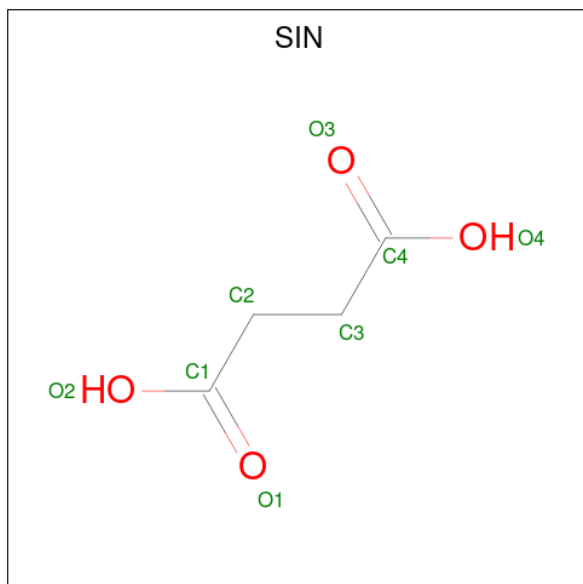| Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total 4	C 2	O 2	0	0
2	A	1	Total 4	C 2	O 2	0	0
2	A	1	Total 4	C 2	O 2	0	0

- Molecule 3 is [(1S,5R)-8-methyl-8-azabicyclo[3.2.1]octan-3-yl] (2S)-3-hydroxy-2-phen

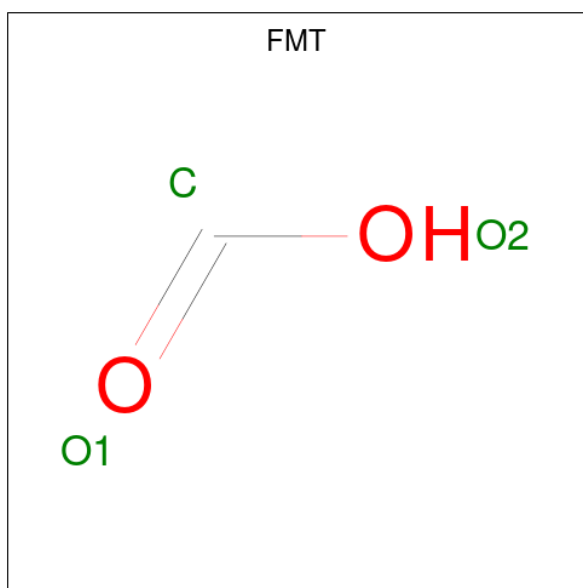ylpropanoate (CCD ID: HYO) (formula: $C_{17}H_{23}NO_3$) (labeled as "Ligand of Interest" by depositor).

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

- Molecule 4 is SUCCINIC ACID (CCD ID: SIN) (formula: $C_4H_6O_4$) (labeled as "Ligand of Interest" by depositor).

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

- Molecule 5 is FORMIC ACID (CCD ID: FMT) (formula: CH_2O_2).

Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
5	A	1	Total 3	C 1	O 2	0	0
5	A	1	Total 3	C 1	O 2	0	0
5	A	1	Total 3	C 1	O 2	0	0
5	A	1	Total 3	C 1	O 2	0	0
5	A	1	Total 3	C 1	O 2	0	0

- Molecule 6 is VANADIUM ION (CCD ID: V) (formula: V) (labeled as "Ligand of Interest" by depositor).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	1	Total 1	V 1	0	0

- Molecule 7 is OXYGEN ATOM (CCD ID: O) (formula: O) (labeled as "Ligand of Interest" by depositor).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
7	A	1	Total 1	O 1	0	0

- Molecule 8 is STRONTIUM ION (CCD ID: SR) (formula: Sr).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
8	A	2	Total Sr 2 2		0	0

• Molecule 9 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
9	A	295	Total O 295 295		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: Hyoscyamine 6-beta-hydroxylase

4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α, β, γ	44.97Å 79.66Å 56.02Å 90.00° 111.30° 90.00°	Depositor
Resolution (Å)	28.09 – 1.79 28.09 – 1.79	Depositor EDS
% Data completeness (in resolution range)	99.7 (28.09-1.79) 99.8 (28.09-1.79)	Depositor EDS
R_{merge}	0.09	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	22.15 (at 1.79Å)	Xtriage
Refinement program	REFMAC 5.8.0267	Depositor
R, R_{free}	0.174 , 0.192 0.184 , 0.201	Depositor DCC
R_{free} test set	1840 reflections (5.30%)	wwPDB-VP
Wilson B-factor (Å^2)	14.2	Xtriage
Anisotropy	0.058	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.37 , 38.4	EDS
L-test for twinning[2]	$< |L| > = 0.50, < L^2 > = 0.33$	Xtriage
Estimated twinning fraction	0.022 for h,-k,-h-l	Xtriage
F_o,F_c correlation	0.95	EDS
Total number of atoms	2942	wwPDB-VP
Average B, all atoms (Å^2)	17.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.75% of the height of the origin peak. No significant pseudotranslation is detected.*

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[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 ⓘ

5.1 Standard geometry ⓘ

Bond lengths and bond angles in the following residue types are not validated in this section: SR, FMT, EDO, HYO, O, SIN, V

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	0.95	0/2648	1.22	0/3600

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	A	0	1

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	217	HIS	Peptide

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	2587	0	2565	9	0
2	A	12	0	18	0	0

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W O R L D W I D E
wwPDB
PROTEIN DATA BANK

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
3	A	21	0	0	0	0
4	A	8	0	4	0	0
5	A	15	0	5	2	0
6	A	1	0	0	0	0
7	A	1	0	0	0	0
8	A	2	0	0	0	0
9	A	295	0	0	2	0
All	All	2942	0	2592	10	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 2.

All (10) 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:407:FMT:O1	9:A:501:HOH:O	2.17	0.58
1:A:309:ASN:ND2	5:A:407:FMT:O2	2.41	0.54
1:A:60:LEU:C	1:A:60:LEU:HD23	2.39	0.48
1:A:314:LYS:NZ	9:A:510:HOH:O	2.49	0.46
1:A:55:CYS:SG	1:A:256:LEU:HD11	2.57	0.45
1:A:150:LYS:HA	1:A:151:PRO:C	2.42	0.44
1:A:32:GLY:HA3	1:A:243:ILE:HD13	2.01	0.43
1:A:190:GLU:HA	1:A:193:GLN:HG2	2.00	0.42
1:A:226:LEU:HD13	1:A:226:LEU:C	2.46	0.41
1:A:337:LYS:N	1:A:338:PRO:CD	2.83	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	320/385 (83%)	312 (98%)	8 (2%)	0	100	100

There are no Ramachandran outliers to report.

5.3.2   Protein sidechains ⓘ

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	288/326 (88%)	288 (100%)	0	100	100

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

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (3) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	42	GLN
1	A	50	GLN
1	A	235	GLN

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 oligosaccharides in this entry.

5.6   Ligand geometry ⓘ

Of 14 ligands modelled in this entry, 4 are monoatomic - leaving 10 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	$\#|Z| > 2$
2	EDO	A	406	-	3,3,3	0.05	0	2,2,2	0.22	0
2	EDO	A	405	-	3,3,3	0.12	0	2,2,2	0.10	0
5	FMT	A	407	-	2,2,2	0.19	0	1,1,1	0.19	0
5	FMT	A	409	-	2,2,2	0.32	0	1,1,1	0.16	0
5	FMT	A	408	-	2,2,2	0.27	0	1,1,1	0.15	0
4	SIN	A	403	6	7,7,7	1.12	0	8,8,8	0.92	0
3	HYO	A	402	-	23,23,23	1.03	1 (4%)	32,32,32	0.68	1 (3%)
5	FMT	A	410	-	2,2,2	0.32	0	1,1,1	0.14	0
2	EDO	A	401	-	3,3,3	0.04	0	2,2,2	0.15	0
5	FMT	A	404	-	2,2,2	0.25	0	1,1,1	0.16	0

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	EDO	A	406	-	-	1/1/1/1	-
2	EDO	A	405	-	-	0/1/1/1	-
4	SIN	A	403	6	-	2/5/5/5	-
3	HYO	A	402	-	-	1/14/35/35	0/4/3/3
2	EDO	A	401	-	-	0/1/1/1	-

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	A	402	HYO	O01-C13	3.81	1.43	1.34

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
3	A	402	HYO	O01-C13-C14	2.01	113.65	111.06

There are no chirality outliers.

All (4) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	A	406	EDO	O1-C1-C2-O2
4	A	403	SIN	C2-C3-C4-O3
4	A	403	SIN	C2-C3-C4-O4
3	A	402	HYO	C13-C14-C16-O03

There are no ring outliers.

1 monomer is involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
5	A	407	FMT	2	0

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 SIN A 403

Bond lengths   Bond angles

Torsions   Rings

Ligand HYO A 402

Bond lengths

Bond angles

Torsions

Rings

5.7 Other polymers ⓘ

There are no such residues in this entry.

5.8 Polymer linkage issues ⓘ

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, 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	326/385 (84%)	0.07	15 (4%)	38	35	8, 14, 27, 42	0

All (15) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	238	GLU	4.2
1	A	13	VAL	3.6
1	A	124	ALA	3.5
1	A	119	GLN	3.0
1	A	123	GLU	2.7
1	A	240	ALA	2.6
1	A	27	ASN	2.4
1	A	139	LEU	2.4
1	A	342	ASN	2.2
1	A	15	GLU	2.2
1	A	308	ASP	2.1
1	A	141	GLU	2.1
1	A	28	ASP	2.0
1	A	241	LYS	2.0
1	A	237	ILE	2.0

6.2 Non-standard residues in protein, DNA, RNA chains ⓘ

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

6.3 Carbohydrates ⓘ

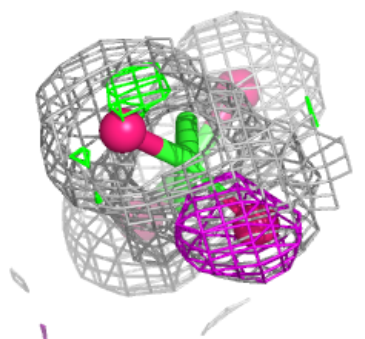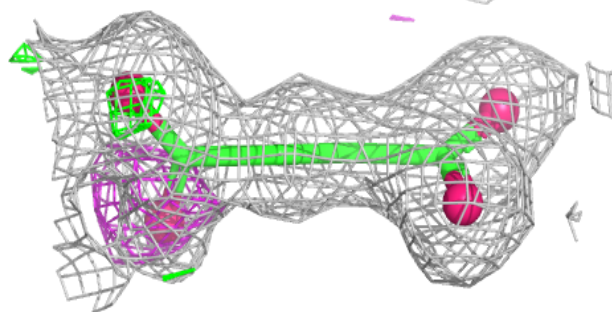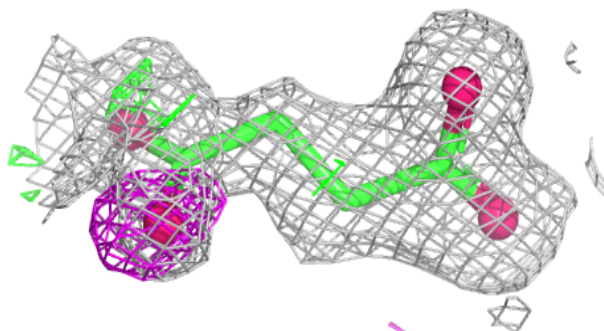There are no monosaccharides in this entry.

6.4 Ligands ⓘ

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.

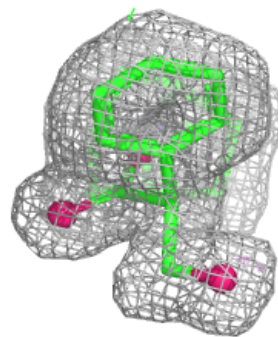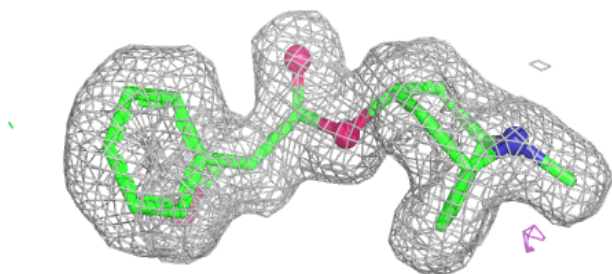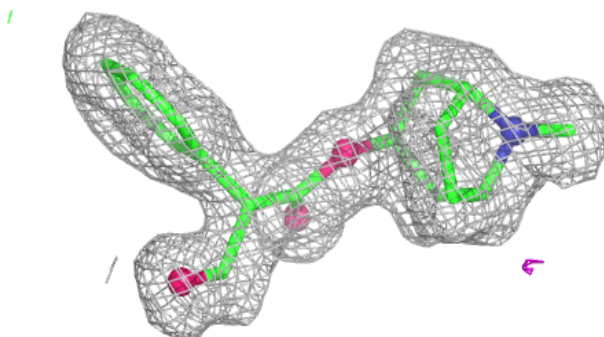| Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å^2)	Q<0.9
5	FMT	A	408	3/3	0.71	0.18	47,47,48,48	0
5	FMT	A	407	3/3	0.73	0.44	48,48,49,51	0
2	EDO	A	406	4/4	0.74	0.18	31,32,32,33	0
5	FMT	A	409	3/3	0.77	0.15	31,31,31,32	0
2	EDO	A	405	4/4	0.78	0.24	32,33,34,34	0
5	FMT	A	410	3/3	0.82	0.13	29,29,30,31	0
5	FMT	A	404	3/3	0.86	0.13	34,34,35,36	0
4	SIN	A	403	8/8	0.89	0.11	13,14,15,16	8
2	EDO	A	401	4/4	0.95	0.08	21,21,22,22	0
3	HYO	A	402	21/21	0.95	0.06	9,10,10,11	0
7	O	A	412	1/1	0.98	0.04	13,13,13,13	0
8	SR	A	413	1/1	0.98	0.10	29,29,29,29	1
6	V	A	411	1/1	1.00	0.01	10,10,10,10	0
8	SR	A	414	1/1	1.00	0.02	10,10,10,10	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 SIN A 403:

$2mF_o$-DF_c (at 0.7 rmsd) in gray
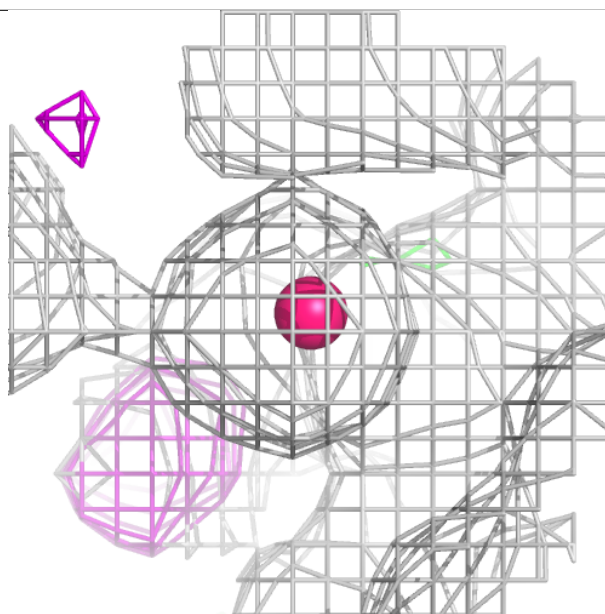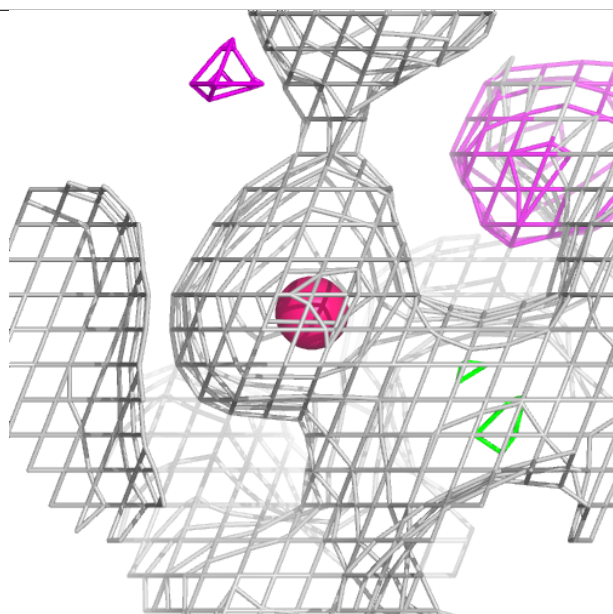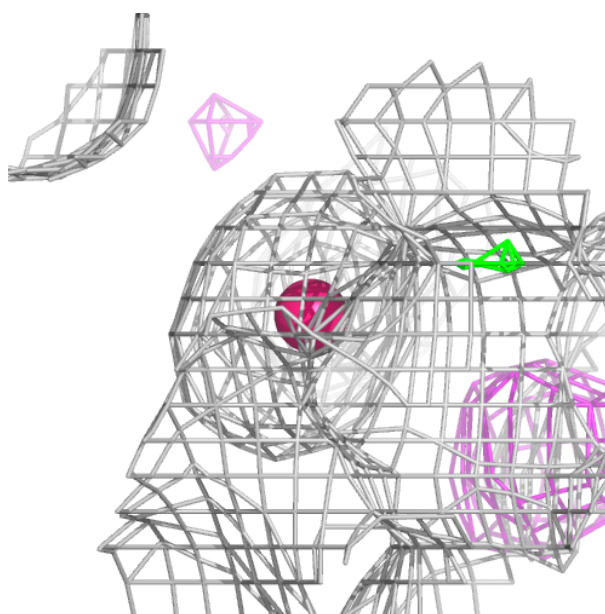mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)

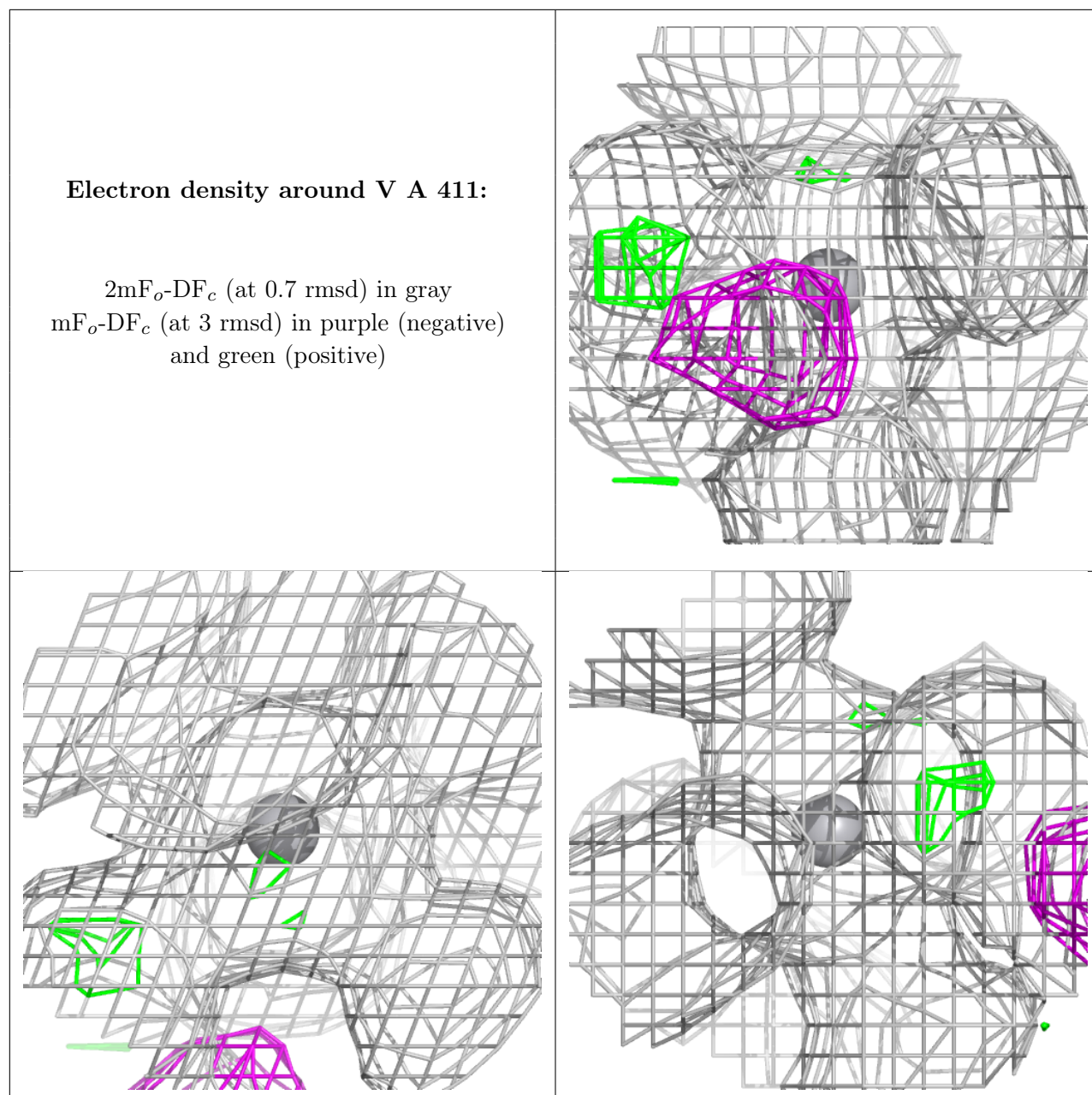**Electron density around HYO A 402:**

$2mF_o$-DF_c (at 0.7 rmsd) in gray
mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)

Electron density around O A 412:

$2mF_o$-DF_c (at 0.7 rmsd) in gray
mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)

Electron density around V A 411:

$2mF_o\text{-}DF_c$ (at 0.7 rmsd) in gray
$mF_o\text{-}DF_c$ (at 3 rmsd) in purple (negative)
and green (positive)

6.5 Other polymers ⓘ

There are no such residues in this entry.