Full wwPDB X-ray Structure Validation Report ⓘ

Aug 18, 2025 – 05:06 PM EDT

PDB ID	:	9C73 / pdb_00009c73
Title	:	Hybrid G-quadruplex from Tetrahymena thermophila telomeric sequence in complex with TrisQO
Authors	:	Ali, A.; Yatsunyk, L.A.
Deposited on	:	2024-06-10
Resolution	:	1.66 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 ⓘ symbol.

The types of validation reports are described at
http://www.wwpdb.org/validation/2017/FAQs#types.

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

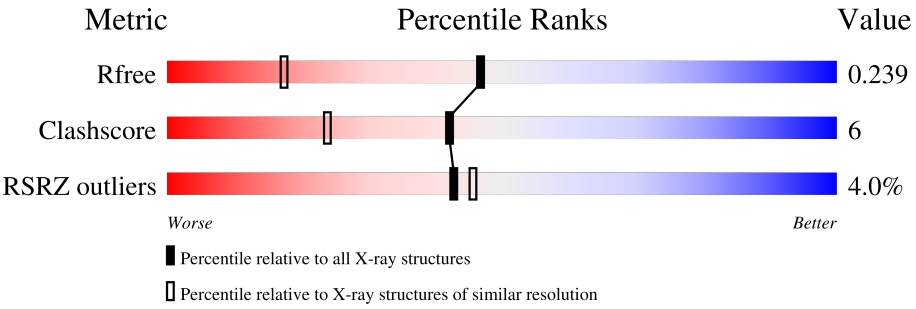
MolProbity	:	4-5-2 with Phenix2.0rc1
Mogul	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	2.0rc1
EDS	:	3.0
buster-report	:	1.1.7 (2018)
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.006 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.45.1

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 1.66 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}	164625	2328 (1.66-1.66)
Clashscore	180529	2515 (1.66-1.66)
RSRZ outliers	164620	2328 (1.66-1.66)

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	25	4% 72% 28%

2 Entry composition

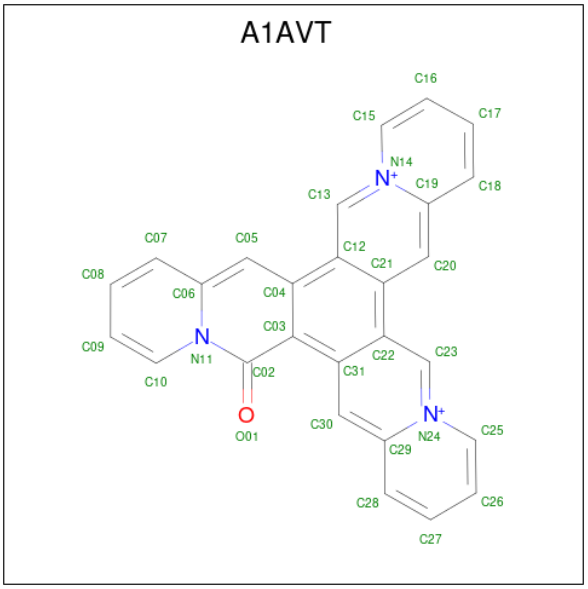
There are 8 unique types of molecules in this entry. The entry contains 719 atoms, of which 0 are hydrogens and 0 are deuteriums.

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 DNA chain called G-quadruplex telomeric sequence.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	P			
1	A	25	531	250	101	156	24	0	0	0

- Molecule 2 is (5S)-6-oxo-6H-dipyrido[1,2-b:1',2'-j]quinolizino[3,2-f][2,8]phenanthroline-12,19-diium (CCD ID: A1AVT) (formula: $C_{27}H_{17}N_3O$) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
			Total	C	N	O		
2	A	1	31	27	3	1	0	0

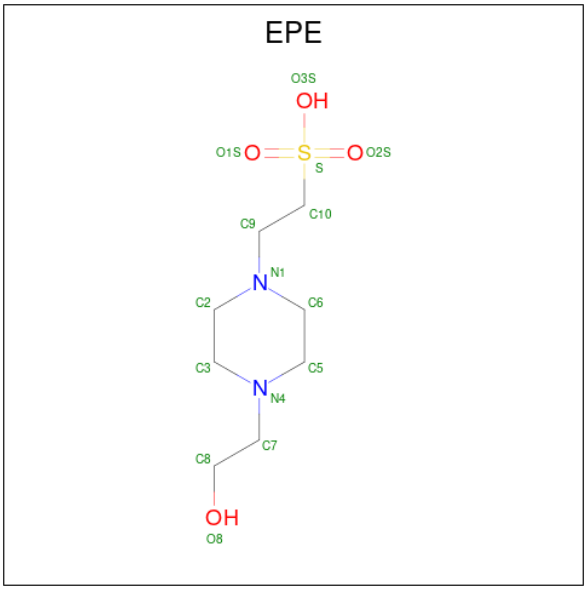
- Molecule 3 is POTASSIUM ION (CCD ID: K) (formula: K).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
			Total	K		
3	A	3	3	3	0	0

- Molecule 4 is CALCIUM ION (CCD ID: CA) (formula: Ca).

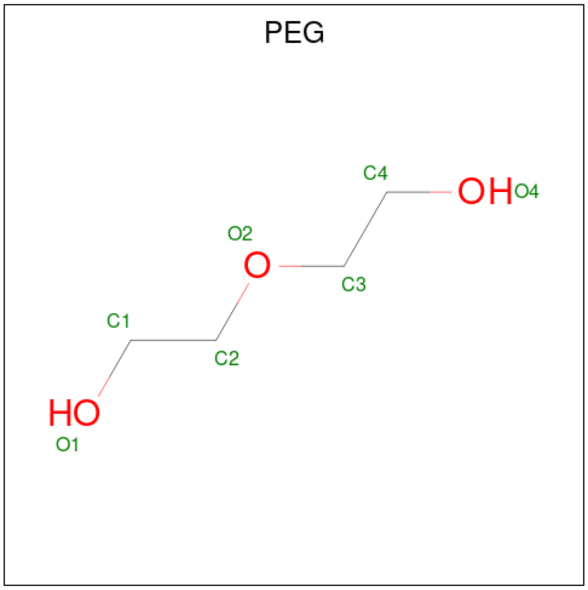
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	A	3	Total Ca 3 3	0	0

- Molecule 5 is 4-(2-HYDROXYETHYL)-1-PIPERAZINE ETHANESULFONIC ACID (CCD ID: EPE) (formula: $C_8H_{18}N_2O_4S$).



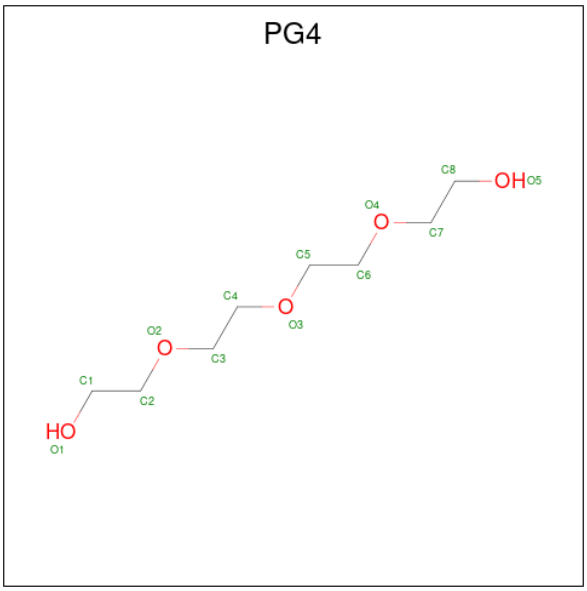
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
5	A	1	Total C N O S 30 16 4 8 2	0	1

- Molecule 6 is DI(HYDROXYETHYL)ETHER (CCD ID: PEG) (formula: $C_4H_{10}O_3$).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
6	A	1	Total C O 7 4 3	0	0
6	A	1	Total C O 7 4 3	0	0
6	A	1	Total C O 7 4 3	0	0
6	A	1	Total C O 7 4 3	0	0
6	A	1	Total C O 7 4 3	0	0
6	A	1	Total C O 7 4 3	0	0
6	A	1	Total C O 7 4 3	0	0

- Molecule 7 is TETRAETHYLENE GLYCOL (CCD ID: PG4) (formula: $C_8H_{18}O_5$).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
7	A	1	Total C O 13 8 5	0	0
7	A	1	Total C O 13 8 5	0	0
7	A	1	Total C O 13 8 5	0	0

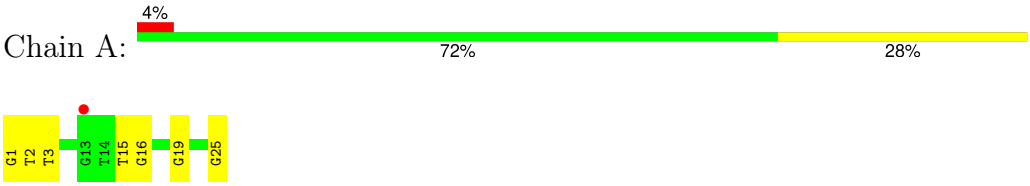
- Molecule 8 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
8	A	33	Total O 33 33	0	0

3 Residue-property plots (i)

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: G-quadruplex telomeric sequence



4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 61 2 2	Depositor
Cell constants a, b, c, α, β, γ	54.91Å 54.91Å 98.70Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	27.46 – 1.66 27.46 – 1.66	Depositor EDS
% Data completeness (in resolution range)	99.6 (27.46-1.66) 99.8 (27.46-1.66)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	1.41 (at 1.65Å)	Xtriage
Refinement program	PHENIX 1.21.1_5286	Depositor
R, R_{free}	0.214 , 0.236 0.217 , 0.239	Depositor DCC
R_{free} test set	580 reflections (5.23%)	wwPDB-VP
Wilson B-factor (Å^2)	32.7	Xtriage
Anisotropy	0.241	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.39 , 65.7	EDS
L-test for twinning[2]	$< \|L\| > = 0.49$, $< L^2 > = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o,F_c correlation	0.96	EDS
Total number of atoms	719	wwPDB-VP
Average B, all atoms (Å^2)	49.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 9.05% 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

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: PEG, CA, A1AVT, K, EPE, PG4

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	0.42	0/597	0.56	0/927

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	531	0	285	6	0
2	A	31	0	0	0	0
3	A	3	0	0	0	0
4	A	3	0	0	0	0
5	A	30	0	35	0	0
6	A	49	0	68	1	0
7	A	39	0	54	2	0
8	A	33	0	0	2	0
All	All	719	0	442	7	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 6.

All (7) 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:19:DG:H21	7:A:114:PG4:H11	1.47	0.80
6:A:109:PEG:O1	8:A:201:HOH:O	2.10	0.69
1:A:25:DG:OP2	8:A:202:HOH:O	2.12	0.67
1:A:1:DG:N3	1:A:1:DG:H2'	2.22	0.54
1:A:19:DG:N2	7:A:114:PG4:H11	2.23	0.47
1:A:2:DT:H2"	1:A:3:DT:OP1	2.15	0.46
1:A:15:DT:H2"	1:A:16:DG:N2	2.31	0.46

There are no symmetry-related clashes.

5.3 Torsion angles

5.3.1 Protein backbone

There are no protein molecules in this entry.

5.3.2 Protein sidechains

There are no protein molecules in this entry.

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 19 ligands modelled in this entry, 6 are monoatomic - leaving 13 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	$\#\|Z\| > 2$
6	PEG	A	113	-	6,6,6	0.25	0	5,5,5	0.20	0
6	PEG	A	111	-	6,6,6	0.23	0	5,5,5	0.27	0
6	PEG	A	109	4	6,6,6	0.26	0	5,5,5	0.31	0
6	PEG	A	112	-	6,6,6	0.24	0	5,5,5	0.27	0
6	PEG	A	118	-	6,6,6	0.25	0	5,5,5	0.23	0
6	PEG	A	117	-	6,6,6	0.24	0	5,5,5	0.27	0
2	A1AVT	A	101	-	37,37,37	2.95	11 (29%)	51,56,56	2.59	23 (45%)
7	PG4	A	114	-	12,12,12	0.31	0	11,11,11	0.18	0
5	EPE	A	108[B]	-	15,15,15	0.72	0	19,20,20	0.86	1 (5%)
6	PEG	A	110	-	6,6,6	0.21	0	5,5,5	0.46	0
7	PG4	A	115	-	12,12,12	0.29	0	11,11,11	0.24	0
7	PG4	A	116	-	12,12,12	0.29	0	11,11,11	0.27	0
5	EPE	A	108[A]	-	15,15,15	0.76	1 (6%)	19,20,20	0.82	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
6	PEG	A	113	-	-	3/4/4/4	-
6	PEG	A	111	-	-	1/4/4/4	-
6	PEG	A	109	4	-	2/4/4/4	-
6	PEG	A	112	-	-	2/4/4/4	-
6	PEG	A	118	-	-	2/4/4/4	-
6	PEG	A	117	-	-	3/4/4/4	-
7	PG4	A	114	-	-	8/10/10/10	-
5	EPE	A	108[B]	-	-	7/9/19/19	0/1/1/1
6	PEG	A	110	-	-	2/4/4/4	-
7	PG4	A	115	-	-	6/10/10/10	-
7	PG4	A	116	-	-	4/10/10/10	-
5	EPE	A	108[A]	-	-	0/9/19/19	0/1/1/1

All (12) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	101	A1AVT	C06-N11	-12.05	1.31	1.39
2	A	101	A1AVT	C19-N14	-6.51	1.29	1.39
2	A	101	A1AVT	C29-N24	-5.77	1.30	1.39
2	A	101	A1AVT	C20-C19	4.08	1.43	1.38
2	A	101	A1AVT	C12-C21	-3.03	1.37	1.42
2	A	101	A1AVT	C23-C22	2.96	1.42	1.37
2	A	101	A1AVT	C30-C29	2.88	1.42	1.38
2	A	101	A1AVT	C13-C12	2.74	1.42	1.38
2	A	101	A1AVT	C03-C31	2.64	1.48	1.43
2	A	101	A1AVT	C30-C31	2.22	1.43	1.40
2	A	101	A1AVT	C10-C09	2.17	1.39	1.35
5	A	108[A]	EPE	C10-S	2.01	1.80	1.77

All (24) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	A	101	A1AVT	C28-C29-C30	-5.60	117.12	123.17
2	A	101	A1AVT	C21-C20-C19	-5.35	117.90	122.02
2	A	101	A1AVT	C18-C19-C20	-5.33	117.40	123.17
2	A	101	A1AVT	C20-C19-N14	5.03	122.07	118.55
2	A	101	A1AVT	C22-C23-N24	-4.76	118.42	121.81
2	A	101	A1AVT	O01-C02-N11	-4.60	116.90	119.93
2	A	101	A1AVT	C30-C29-N24	4.24	121.52	118.55
2	A	101	A1AVT	C23-C22-C21	-4.06	117.78	121.94
2	A	101	A1AVT	C03-C02-N11	3.57	119.50	115.25
2	A	101	A1AVT	C23-C22-C31	3.33	121.93	118.62
2	A	101	A1AVT	C25-N24-C23	-3.30	116.30	119.61
2	A	101	A1AVT	C31-C30-C29	-3.13	119.61	122.02
2	A	101	A1AVT	C26-C27-C28	-3.12	116.23	120.40
2	A	101	A1AVT	C09-C08-C07	-3.07	117.05	121.20
2	A	101	A1AVT	C28-C29-N24	2.94	121.36	118.22
2	A	101	A1AVT	C03-C04-C12	2.72	121.24	118.61
2	A	101	A1AVT	C30-C31-C22	-2.63	116.16	119.14
2	A	101	A1AVT	C04-C03-C31	-2.38	117.82	120.47
2	A	101	A1AVT	C15-N14-C19	2.32	121.92	119.86
2	A	101	A1AVT	C20-C21-C12	2.20	120.01	117.78
5	A	108[B]	EPE	C3-C2-N1	2.19	115.07	110.65
2	A	101	A1AVT	C17-C18-C19	-2.16	119.75	121.19
2	A	101	A1AVT	C18-C19-N14	2.15	120.52	118.22
2	A	101	A1AVT	C07-C06-C05	-2.08	117.26	119.99

There are no chirality outliers.

All (40) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
5	A	108[B]	EPE	C10-C9-N1-C2
5	A	108[B]	EPE	S-C10-C9-N1
5	A	108[B]	EPE	C9-C10-S-O2S
5	A	108[B]	EPE	C8-C7-N4-C3
7	A	116	PG4	O3-C5-C6-O4
7	A	115	PG4	O3-C5-C6-O4
6	A	110	PEG	O1-C1-C2-O2
7	A	115	PG4	O2-C3-C4-O3
7	A	114	PG4	O2-C3-C4-O3
5	A	108[B]	EPE	C9-C10-S-O3S
6	A	110	PEG	O2-C3-C4-O4
7	A	115	PG4	O1-C1-C2-O2
6	A	117	PEG	O2-C3-C4-O4
7	A	114	PG4	O4-C7-C8-O5
6	A	113	PEG	O1-C1-C2-O2
6	A	117	PEG	O1-C1-C2-O2
7	A	114	PG4	O3-C5-C6-O4
7	A	114	PG4	O1-C1-C2-O2
6	A	109	PEG	O2-C3-C4-O4
5	A	108[B]	EPE	C9-C10-S-O1S
7	A	116	PG4	O4-C7-C8-O5
7	A	116	PG4	C6-C5-O3-C4
6	A	111	PEG	O1-C1-C2-O2
7	A	114	PG4	C4-C3-O2-C2
6	A	109	PEG	C4-C3-O2-C2
7	A	115	PG4	C1-C2-O2-C3
7	A	116	PG4	C1-C2-O2-C3
7	A	114	PG4	C5-C6-O4-C7
6	A	112	PEG	O1-C1-C2-O2
7	A	114	PG4	C3-C4-O3-C5
6	A	113	PEG	C4-C3-O2-C2
5	A	108[B]	EPE	C10-C9-N1-C6
7	A	115	PG4	C5-C6-O4-C7
7	A	114	PG4	C1-C2-O2-C3
6	A	117	PEG	C1-C2-O2-C3
6	A	112	PEG	C4-C3-O2-C2
7	A	115	PG4	C6-C5-O3-C4
6	A	113	PEG	O2-C3-C4-O4
6	A	118	PEG	C1-C2-O2-C3
6	A	118	PEG	C4-C3-O2-C2

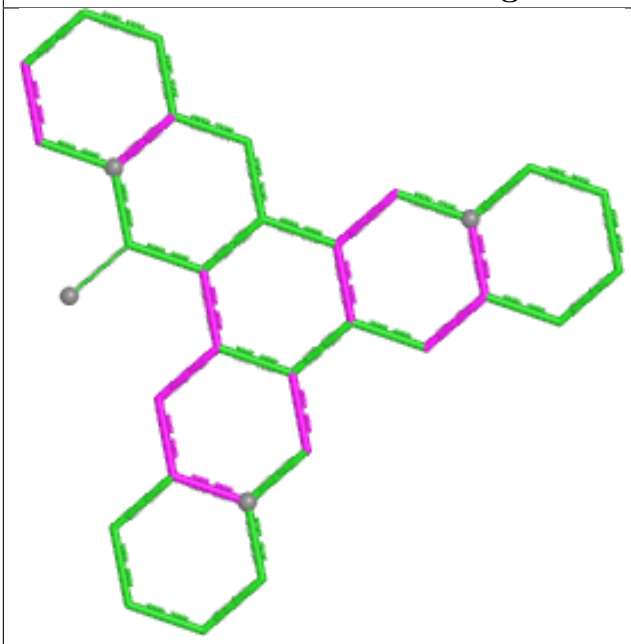
There are no ring outliers.

2 monomers are involved in 3 short contacts:

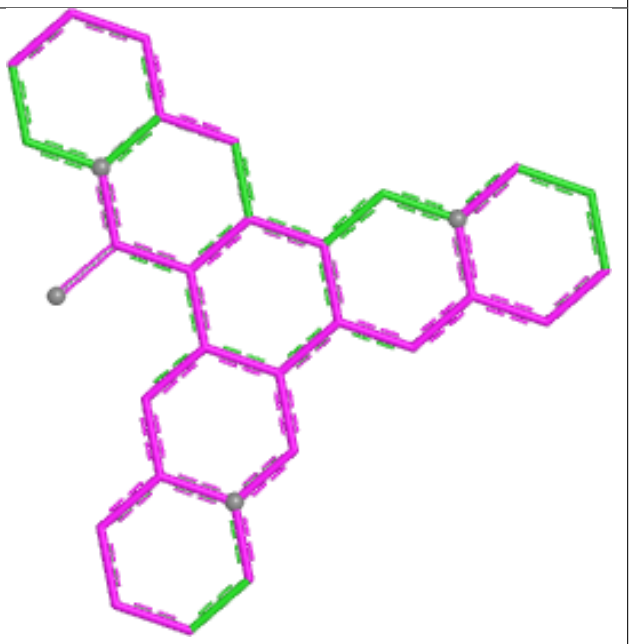
Mol	Chain	Res	Type	Clashes	Symm-Clashes
6	A	109	PEG	1	0
7	A	114	PG4	2	0

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.

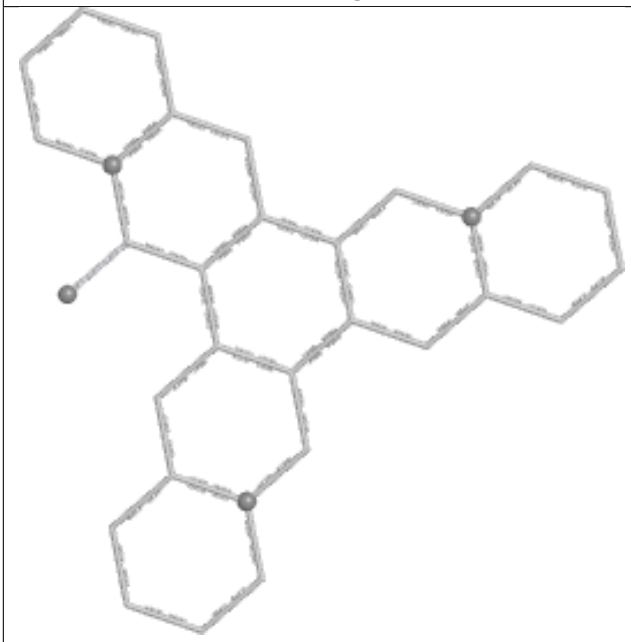
Ligand A1AVT A 101



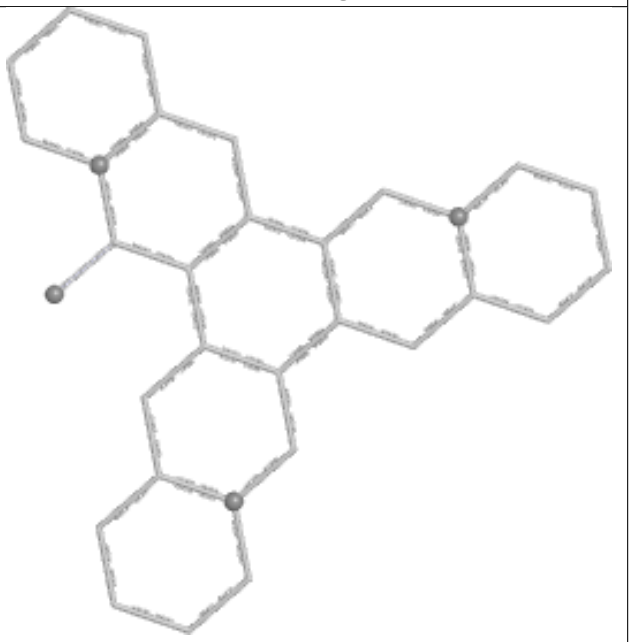
Bond lengths



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, 95^{th} 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	25/25 (100%)	0.27	1 (4%) 43 46	36, 44, 60, 81	0

All (1) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	13	DG	2.5

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 oligosaccharides 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, 95^{th} 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
6	PEG	A	113	7/7	0.62	0.18	84,88,92,95	0
6	PEG	A	112	7/7	0.71	0.18	86,90,96,100	0
6	PEG	A	117	7/7	0.71	0.17	90,99,106,113	0
7	PG4	A	115	13/13	0.71	0.24	68,78,85,89	0
6	PEG	A	110	7/7	0.76	0.26	64,67,74,77	0
6	PEG	A	118	7/7	0.78	0.18	83,84,89,91	0

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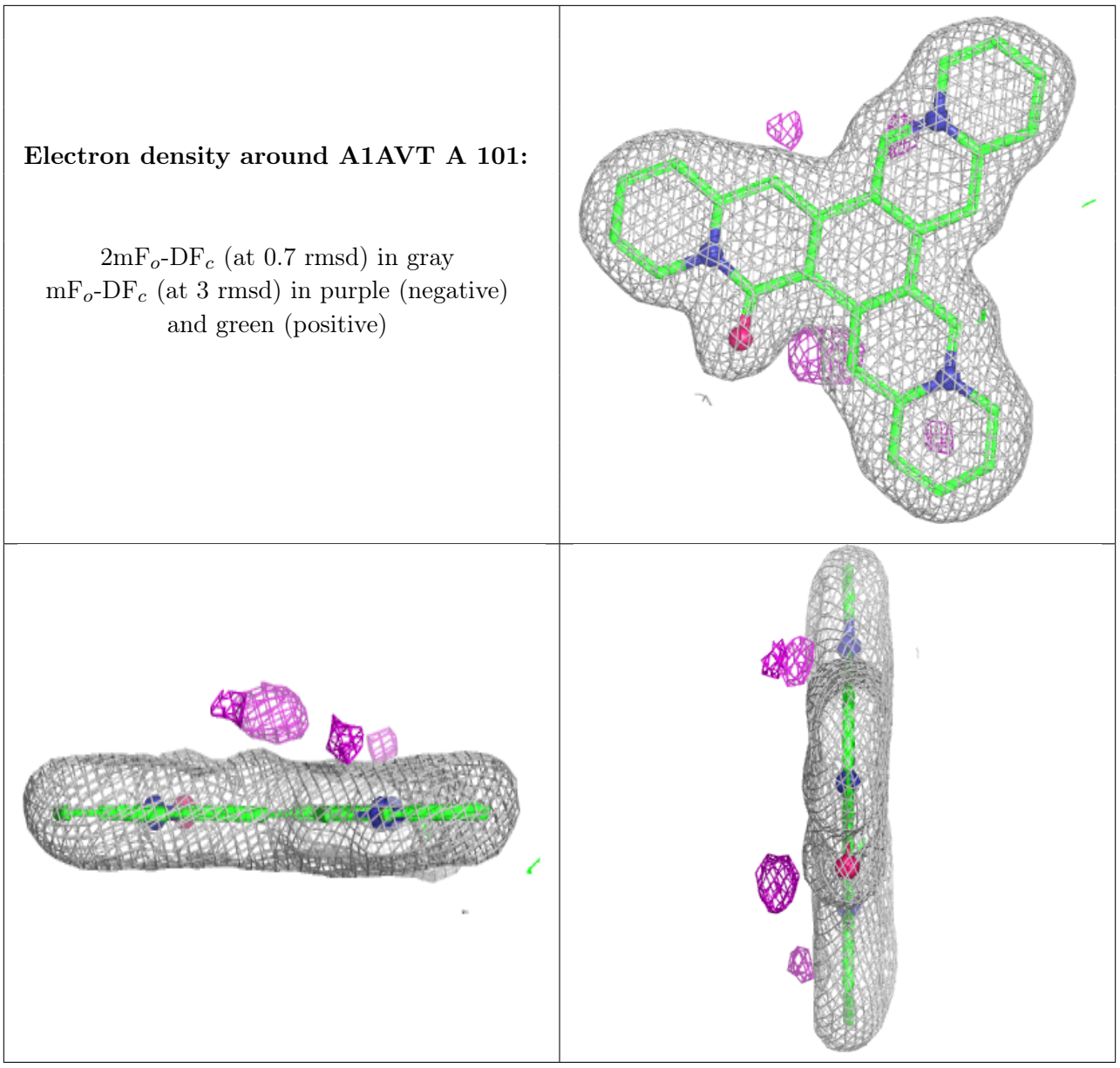
Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å^2)	Q<0.9
6	PEG	A	111	7/7	0.80	0.14	68,72,84,92	0
6	PEG	A	109	7/7	0.80	0.18	47,49,51,53	0
7	PG4	A	114	13/13	0.81	0.18	54,63,71,71	0
7	PG4	A	116	13/13	0.81	0.16	56,60,69,69	0
5	EPE	A	108[A]	15/15	0.90	0.18	36,38,43,45	15
5	EPE	A	108[B]	15/15	0.90	0.18	32,37,39,41	15
2	A1AVT	A	101	31/31	0.94	0.09	28,31,36,38	0
4	CA	A	106	1/1	0.94	0.11	53,53,53,53	0
4	CA	A	107	1/1	0.97	0.07	42,42,42,42	0
4	CA	A	105	1/1	0.99	0.04	39,39,39,39	0
3	K	A	103	1/1	0.99	0.03	29,29,29,29	0
3	K	A	104	1/1	0.99	0.06	33,33,33,33	0
3	K	A	102	1/1	1.00	0.03	27,27,27,27	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 A1AVT A 101:

$2mF_o$-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.