



Full wwPDB NMR Structure Validation Report ⓘ

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PDB ID : 1AUL / pdb_00001aul
Title : SOLUTION STRUCTURE OF A HIGHLY STABLE DNA DUPLEX CONJUGATED TO A MINOR GROOVE BINDER, NMR, MINIMIZED AVERAGE STRUCTURE
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Deposited on : 1997-08-29

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A user guide is available at

<https://www.wwpdb.org/validation/2017/NMRValidationReportHelp>

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 Phenix2.0
Mogul : 2022.3.0, CSD as543be (2022)
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
wwPDB-RCI : v_1n_11_5_13_A (Berjanski et al., 2005)
PANAV : Wang et al. (2010)
wwPDB-ShiftChecker : v1.2
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.49

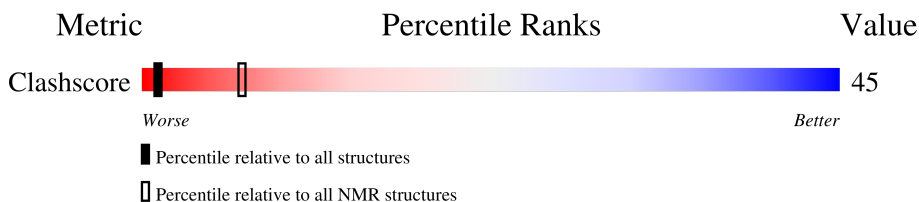
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

SOLUTION NMR


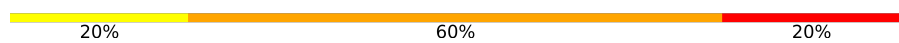
The overall completeness of chemical shifts assignment was not calculated.

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)	NMR archive (#Entries)
Clashscore	229148	14424

The table below summarises the geometric issues observed across the polymeric chains and their fit to the experimental data. The red, orange, yellow and green segments indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria. A cyan segment indicates the fraction of residues that are not part of the well-defined cores, and 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 $\leq 5\%$

Mol	Chain	Length	Quality of chain
1	A	10	
2	B	10	

2 Ensemble composition and analysis

This entry contains 1 models. Identification of well-defined residues and clustering analysis are not possible.

3 Entry composition [i](#)

There are 2 unique types of molecules in this entry. The entry contains 729 atoms, of which 269 are hydrogens and 0 are deuteriums.

- Molecule 1 is a DNA chain called DNA (5'-D(P*THXP*GP*AP*TP*TP*AP*TP*CP*TP*G)-3').

Mol	Chain	Residues	Atoms						Trace
			Total	C	H	N	O	P	
1	A	10	413	139	155	41	68	10	0

- Molecule 2 is a DNA chain called DNA (5'-D(*CP*AP*GP*AP*TP*AP*AP*TP*CP*A)-3').

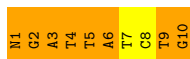
Mol	Chain	Residues	Atoms						Trace
			Total	C	H	N	O	P	
2	B	10	316	98	114	40	55	9	0

4 Residue-property plots [i](#)

These plots are provided for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic is the same as shown in the summary in section 1 of this report. The second graphic shows the sequence where residues are colour-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. Stretches of 2 or more consecutive residues without any outliers are shown as green connectors. Residues which are classified as ill-defined in the NMR ensemble, are shown in cyan with an underline colour-coded according to the previous scheme. Residues which were present in the experimental sample, but not modelled in the final structure are shown in grey.

- Molecule 1: DNA (5'-D(P*THXP*GP*AP*TP*TP*AP*TP*CP*TP*G)-3')

Chain A: 



- Molecule 2: DNA (5'-D(*CP*AP*GP*AP*TP*AP*AP*TP*CP*A)-3')

Chain B: 



5 Refinement protocol and experimental data overview

The models were refined using the following method: *RESTRAINED MOLECULAR DYNAMICS/RELAXATION MATRIX REFINEMENT*.

Of the 6 calculated structures, 1 were deposited, based on the following criterion: *LEAST RESTRAINT VIOLATION*.

The following table shows the software used for structure solution, optimisation and refinement.

Software name	Classification	Version
X-PLOR	refinement	
X-PLOR	structure solution	3.1

No chemical shift data was provided.

6 Model quality i

6.1 Standard geometry i

Bond lengths and bond angles in the following residue types are not validated in this section: THX

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 (average) 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	2.33	18/206 (8.7%)	1.48	1/316 (0.3%)
2	B	2.31	18/227 (7.9%)	1.41	1/348 (0.3%)
All	All	2.32	36/433 (8.3%)	1.44	2/664 (0.3%)

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	Planarity
2	B	0	2
All	All	0	2

All bond outliers are listed below. They are sorted according to the Z-score.

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	B	18	DT	O3'-P	9.68	1.75	1.61
2	B	11	DC	O3'-P	8.69	1.74	1.61
2	B	19	DC	O3'-P	8.58	1.74	1.61
1	A	7	DT	O3'-P	8.44	1.73	1.61
1	A	9	DT	O3'-P	8.36	1.73	1.61
1	A	3	DA	O3'-P	8.29	1.73	1.61
2	B	14	DA	O3'-P	8.27	1.73	1.61
1	A	8	DC	O3'-P	8.21	1.73	1.61
1	A	2	DG	O3'-P	8.18	1.73	1.61
1	A	6	DA	O3'-P	8.12	1.73	1.61
2	B	13	DG	O3'-P	8.09	1.73	1.61
2	B	15	DT	O3'-P	8.04	1.73	1.61
2	B	12	DA	O3'-P	7.96	1.73	1.61
1	A	4	DT	O3'-P	7.84	1.73	1.61
2	B	17	DA	O3'-P	7.83	1.72	1.61

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	B	16	DA	O3'-P	7.72	1.72	1.61
1	A	5	DT	O3'-P	7.67	1.72	1.61
2	B	18	DT	P-O5'	7.19	1.74	1.60
1	A	2	DG	P-O5'	7.12	1.74	1.60
2	B	19	DC	P-O5'	6.91	1.74	1.60
2	B	15	DT	P-O5'	6.80	1.74	1.60
1	A	8	DC	P-O5'	6.65	1.73	1.60
1	A	4	DT	P-O5'	6.64	1.73	1.60
2	B	12	DA	P-O5'	6.63	1.73	1.60
1	A	10	DG	P-O5'	6.58	1.73	1.60
1	A	7	DT	P-O5'	6.50	1.73	1.60
2	B	16	DA	P-O5'	6.49	1.73	1.60
1	A	6	DA	C3'-C2'	6.37	1.65	1.52
2	B	13	DG	P-O5'	6.36	1.73	1.60
1	A	6	DA	P-O5'	6.35	1.73	1.60
1	A	9	DT	P-O5'	6.31	1.73	1.60
2	B	20	DA	P-O5'	6.29	1.73	1.60
2	B	14	DA	P-O5'	6.29	1.73	1.60
1	A	3	DA	P-O5'	6.29	1.73	1.60
2	B	17	DA	P-O5'	5.88	1.72	1.60
1	A	5	DT	P-O5'	5.81	1.72	1.60

All angle outliers are listed below. They are sorted according to the Z-score.

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	6	DA	C5'-C4'-C3'	-5.93	106.00	114.90
2	B	20	DA	C5'-C4'-C3'	-5.10	107.25	114.90

There are no chirality outliers.

All planar outliers are listed below.

Mol	Chain	Res	Type	Group
2	B	19	DC	Sidechain
2	B	20	DA	Sidechain

6.2 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 each 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 averaged over the ensemble.

Mol	Chain	Non-H	H(model)	H(added)	Clashes
1	A	258	155	153	28
2	B	202	114	114	19
All	All	460	269	267	33

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 45.

All clashes are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Clash(Å)	Distance(Å)
1:A:1:THX:H452	2:B:17:DA:O4'	0.80	1.75
1:A:1:THX:H332	2:B:18:DT:O2	0.71	1.84
1:A:1:THX:H232	2:B:19:DC:O2	0.58	1.97
2:B:19:DC:H2''	2:B:20:DA:C5	0.58	2.33
1:A:3:DA:C2	2:B:18:DT:O2	0.57	2.57
1:A:4:DT:O2	2:B:17:DA:H2	0.57	1.83
2:B:19:DC:H2''	2:B:20:DA:C4	0.56	2.35
1:A:1:THX:H442	2:B:17:DA:N3	0.56	2.16
1:A:9:DT:H2''	1:A:10:DG:OP2	0.56	2.00
1:A:2:DG:N2	2:B:19:DC:N3	0.55	2.54
1:A:9:DT:C2	1:A:10:DG:N7	0.53	2.77
1:A:1:THX:H26	1:A:3:DA:C2	0.53	2.39
1:A:3:DA:N1	2:B:18:DT:O2	0.53	2.42
1:A:9:DT:C2	1:A:10:DG:C8	0.52	2.98
1:A:1:THX:H231	1:A:3:DA:N3	0.52	2.19
1:A:1:THX:C11	1:A:1:THX:O6	0.51	2.57
1:A:4:DT:O2	2:B:17:DA:C2	0.51	2.64
1:A:1:THX:H331	1:A:3:DA:C2	0.51	2.41
1:A:2:DG:N2	2:B:19:DC:C2	0.51	2.79
2:B:11:DC:H2''	2:B:12:DA:O5'	0.51	2.05
1:A:9:DT:O2	1:A:10:DG:C8	0.49	2.66
2:B:19:DC:C2'	2:B:20:DA:C5	0.48	2.96
1:A:1:THX:C33	2:B:18:DT:O2	0.48	2.59
1:A:1:THX:C22	1:A:2:DG:N2	0.47	2.78
1:A:1:THX:C12	1:A:2:DG:H4'	0.44	2.42
1:A:1:THX:O6	1:A:1:THX:H112	0.44	2.13
1:A:5:DT:H2''	1:A:6:DA:OP2	0.44	2.11
1:A:1:THX:H26	1:A:3:DA:N3	0.44	2.27
1:A:6:DA:C2	2:B:16:DA:C2	0.44	3.06
1:A:3:DA:N1	2:B:18:DT:C2	0.42	2.87
1:A:1:THX:N4	1:A:1:THX:H4'	0.41	2.30
2:B:12:DA:C2	2:B:13:DG:C4	0.40	3.10
1:A:2:DG:N2	2:B:19:DC:O2	0.40	2.55

6.3 Torsion angles [i](#)

6.3.1 Protein backbone [i](#)

There are no protein molecules in this entry.

6.3.2 Protein sidechains [i](#)

There are no protein molecules in this entry.

6.3.3 RNA [i](#)

There are no RNA molecules in this entry.

6.4 Non-standard residues in protein, DNA, RNA chains [i](#)

1 non-standard protein/DNA/RNA residue is modelled in this entry.

In the following table, the Counts columns list the number of bonds for which Mogul statistics could be retrieved, the number of bonds that are observed in the model and the number of bonds 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 is the number of standard deviations the observed value is removed from the expected value. A bond length with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the average root-mean-square of all Z scores of the bond lengths.

Mol	Type	Chain	Res	Link	Bond lengths		
					Counts	RMSZ	#Z>2
1	THX	A	1	1	79,83,83	4.50	37 (46%)

In the following table, the Counts columns list the number of angles for which Mogul statistics could be retrieved, the number of angles that are observed in the model and the number of 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 angle is the number of standard deviations the observed value is removed from the expected value. A bond angle with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the average root-mean-square of all Z scores of the bond angles.

Mol	Type	Chain	Res	Link	Bond angles		
					Counts	RMSZ	#Z>2
1	THX	A	1	1	107,125,125	5.28	53 (49%)

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	THX	A	1	1	-	0,46,85,85	0,11,11,11

All bond outliers are listed below. They are sorted according to the Z-score.

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	1	THX	C15-C14	12.60	1.57	1.37
1	A	1	THX	C26-C25	12.50	1.57	1.37
1	A	1	THX	C38-C39	11.81	1.29	1.41
1	A	1	THX	C16-C17	11.61	1.30	1.41
1	A	1	THX	C37-C36	11.46	1.55	1.37
1	A	1	THX	C27-C28	9.68	1.32	1.41
1	A	1	THX	C30-C31	8.47	1.52	1.39
1	A	1	THX	C19-C20	8.26	1.52	1.39
1	A	1	THX	C41-C42	8.05	1.52	1.39
1	A	1	THX	C35-N8	7.15	1.45	1.36
1	A	1	THX	C36-N9	6.46	1.47	1.38
1	A	1	THX	C40-C39	6.24	1.49	1.39
1	A	1	THX	C29-C28	5.95	1.49	1.39
1	A	1	THX	C16-C21	5.94	1.31	1.40
1	A	1	THX	C14-N5	5.79	1.46	1.38
1	A	1	THX	C22-C21	5.59	1.41	1.51
1	A	1	THX	C18-C17	5.57	1.48	1.39
1	A	1	THX	C25-N7	5.39	1.45	1.38
1	A	1	THX	C44-C43	5.35	1.41	1.51
1	A	1	THX	C38-C43	4.78	1.33	1.40
1	A	1	THX	C24-N6	4.37	1.41	1.36
1	A	1	THX	C33-C32	3.89	1.44	1.51
1	A	1	THX	C41-C40	3.85	1.45	1.38
1	A	1	THX	C6-N1	3.77	1.44	1.38
1	A	1	THX	P-O3P	3.67	1.73	1.59
1	A	1	THX	P-O5'	3.60	1.73	1.59
1	A	1	THX	C13-N4	3.47	1.39	1.33
1	A	1	THX	C30-C29	3.31	1.44	1.38
1	A	1	THX	C1'-N1	3.03	1.55	1.48
1	A	1	THX	C23-C22	3.01	1.58	1.53
1	A	1	THX	C46-N15	2.89	1.38	1.34
1	A	1	THX	C27-C32	2.66	1.36	1.40
1	A	1	THX	C20-N6	2.35	1.35	1.39
1	A	1	THX	C2-N1	2.35	1.42	1.38
1	A	1	THX	C2'-C1'	2.30	1.58	1.52

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	1	THX	C42-N10	2.17	1.35	1.39
1	A	1	THX	C31-N8	2.17	1.35	1.39

All angle outliers are listed below. They are sorted according to the Z-score.

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	1	THX	C17-C16-C15	21.18	117.13	106.90
1	A	1	THX	C39-C38-C37	19.92	116.52	106.90
1	A	1	THX	C28-C27-C26	17.38	115.29	106.90
1	A	1	THX	C43-C42-N10	12.68	101.28	109.67
1	A	1	THX	C32-C31-N8	11.83	101.84	109.67
1	A	1	THX	C21-C20-N6	11.46	102.08	109.67
1	A	1	THX	C27-C26-C25	10.10	96.01	107.47
1	A	1	THX	C23-N6-C20	9.76	115.97	109.29
1	A	1	THX	C45-N10-C42	9.65	115.89	109.29
1	A	1	THX	C27-C28-N7	9.61	113.73	107.46
1	A	1	THX	C16-C15-C14	9.37	96.84	107.47
1	A	1	THX	C38-C37-C36	9.28	96.93	107.47
1	A	1	THX	C16-C17-N5	8.80	113.20	107.46
1	A	1	THX	C38-C39-N9	8.40	112.94	107.46
1	A	1	THX	C34-N8-C31	7.91	114.71	109.29
1	A	1	THX	C33-C34-N8	7.25	98.61	104.96
1	A	1	THX	C17-N5-C14	6.16	102.40	109.01
1	A	1	THX	C22-C23-N6	5.99	99.71	104.96
1	A	1	THX	C22-C21-C16	5.71	118.88	129.60
1	A	1	THX	C39-N9-C36	5.65	102.95	109.01
1	A	1	THX	C44-C43-C38	5.55	119.18	129.60
1	A	1	THX	C29-C28-N7	5.48	119.75	130.83
1	A	1	THX	C28-N7-C25	5.24	103.39	109.01
1	A	1	THX	C12-N4-C13	5.18	111.11	122.47
1	A	1	THX	C29-C28-C27	4.89	126.52	122.66
1	A	1	THX	C40-C39-N9	4.74	121.24	130.83
1	A	1	THX	C6-C5-C4	4.74	121.93	118.02
1	A	1	THX	C18-C17-N5	4.71	121.31	130.83
1	A	1	THX	C44-C45-N10	4.54	100.98	104.96
1	A	1	THX	C33-C32-C27	3.99	122.11	129.60
1	A	1	THX	C40-C39-C38	3.97	125.80	122.66
1	A	1	THX	C18-C17-C16	3.54	125.46	122.66
1	A	1	THX	C34-C33-C32	3.35	99.19	103.21
1	A	1	THX	C6-N1-C2	3.01	118.30	121.30
1	A	1	THX	O8-C35-N8	2.99	116.41	122.02
1	A	1	THX	C5M-C5-C4	2.83	115.76	118.78

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	1	THX	C19-C18-C17	2.77	114.23	119.57
1	A	1	THX	C41-C40-C39	2.73	114.29	119.57
1	A	1	THX	C41-C42-N10	2.70	136.04	130.42
1	A	1	THX	C2'-C3'-C4'	2.70	108.28	102.80
1	A	1	THX	O7-C24-N6	2.69	116.95	122.02
1	A	1	THX	C30-C29-C28	2.62	114.51	119.57
1	A	1	THX	C26-C25-N7	2.44	111.57	109.15
1	A	1	THX	C19-C20-N6	2.34	135.28	130.42
1	A	1	THX	C5-C6-N1	2.34	120.77	123.31
1	A	1	THX	C1'-N1-C6	2.29	124.59	120.74
1	A	1	THX	C23-N6-C24	2.29	120.61	124.53
1	A	1	THX	C31-N8-C35	2.23	121.05	124.92
1	A	1	THX	C20-N6-C24	2.22	121.07	124.92
1	A	1	THX	C17-C16-C21	2.16	121.87	119.57
1	A	1	THX	C30-C31-N8	2.13	134.85	130.42
1	A	1	THX	C40-C41-C42	2.08	114.93	119.10
1	A	1	THX	C23-C22-C21	2.01	100.79	103.21

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

6.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.6 Ligand geometry [i](#)

There are no ligands in this entry.

6.7 Other polymers [i](#)

There are no such molecules in this entry.

6.8 Polymer linkage issues [i](#)

The following chains have linkage breaks:

Mol	Chain	Number of breaks
2	B	1

All chain breaks are listed below:

Model	Chain	Residue-1	Atom-1	Residue-2	Atom-2	Distance (Å)
1	B	18:DT	O3'	19:DC	P	1.75

7 Chemical shift validation

No chemical shift data were provided