



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 9, 2026 – 10:17 AM UTC

PDB ID : 2D2L / pdb_00002d2l
Title : Crystal Structure of a minimal, all-RNA hairpin ribozyme with a propyl linker (C3) at position U39
Authors : Alam, S.; Grum-Tokars, V.; Krucinska, J.; Kundracik, M.L.; Wedekind, J.E.
Deposited on : 2005-09-11
Resolution : 2.50 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 Phenix2.0
Mogul : 2022.3.0, CSD as543be (2022)
Xtriage (Phenix) : 2.0
EDS : 3.0
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4 : 9.0.010 (Gargrove)
Density-Fitness : 1.0.12
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.49

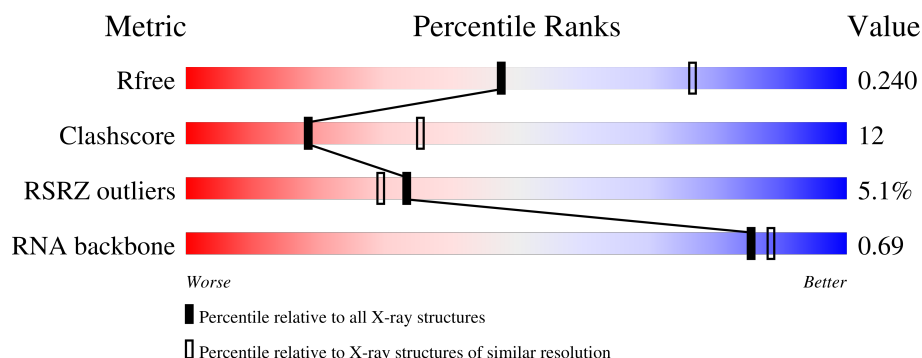
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.50 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}	180053	5829 (2.50-2.50)
Clashscore	190562	6492 (2.50-2.50)
RSRZ outliers	180081	5833 (2.50-2.50)
RNA backbone	3983	1003 (2.78-2.22)

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 $\leq 5\%$. 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	13	8% 54% 8% 38%
2	B	12	50% 50%
3	C	17	82% 18%
4	D	19	11% 32% 53% 16%

2 Entry composition

There are 7 unique types of molecules in this entry. The entry contains 1334 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 RNA chain called 5'-R(*UP*CP*CP*CP*(A2M)P*GP*UP*CP*CP*AP*C P*CP*G)-3'.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	13	Total	C	N	O	P	0	1	0
			285	131	47	95	12			

- Molecule 2 is a RNA chain called 5'-R(*CP*GP*GP*UP*GP*AP*GP*AP*AP*GP*GP*G)-3'.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	B	12	Total	C	N	O	P	0	0	0
			264	118	55	80	11			

- Molecule 3 is a RNA chain called 5'-R(*GP*GP*CP*AP*GP*AP*GP*AP*AP*AP*CP*A P*CP*AP*CP*GP*A)-3'.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	C	17	Total	C	N	O	P	0	0	0
			368	166	77	109	16			

- Molecule 4 is a RNA chain called 5'-R(*UP*CP*GP*UP*GP*GP*UP*AP*(P1P)P*AP*U P*UP*AP*CP*CP*UP*GP*CP*C)-3'.

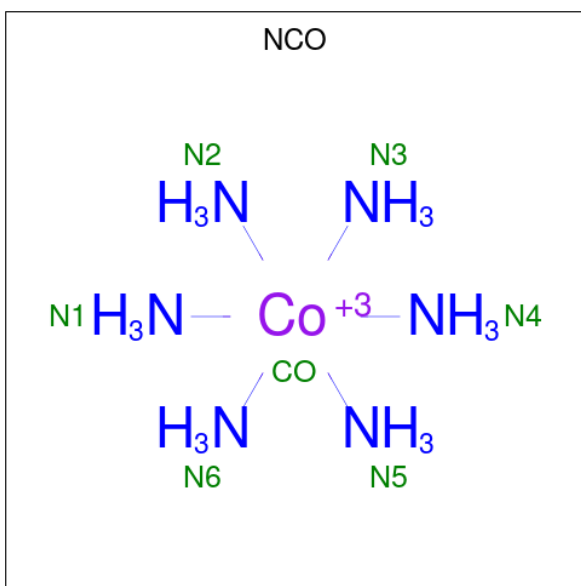
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	D	19	Total	C	N	O	P	0	0	0
			383	172	62	131	18			

- Molecule 5 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
5	A	1	Total	O	S	0	0
			5	4	1		

- Molecule 6 is COBALT HEXAMMINE(III) (CCD ID: NCO) (formula: $\text{CoH}_{18}\text{N}_6$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
6	B	1	Total	Co	N	0	0
			7	1	6		
6	D	1	Total	Co	N	0	0
			7	1	6		
6	D	1	Total	Co	N	0	0
			7	1	6		

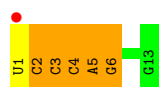
- Molecule 7 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
7	B	2	Total 2	O 2	0	0
7	C	3	Total 3	O 3	0	0
7	D	3	Total 3	O 3	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.

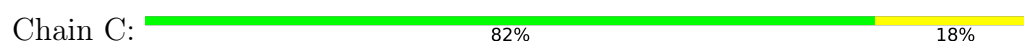
- Molecule 1: 5'-R(*UP*CP*CP*CP*(A2M)P*GP*UP*CP*CP*AP*CP*CP*G)-3'



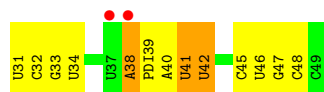
- Molecule 2: 5'-R(*CP*GP*GP*UP*GP*AP*GP*AP*AP*GP*GP*G)-3'



- Molecule 3: 5'-R(*GP*GP*CP*AP*GP*AP*GP*AP*AP*AP*CP*AP*CP*AP*CP*GP*A)-3',



- Molecule 4: 5'-R(*UP*CP*GP*UP*GP*GP*UP*AP*(P1P)P*AP*UP*UP*AP*CP*CP*UP*GP*CP*C)-3'



4 Data and refinement statistics

Property	Value	Source
Space group	P 61 2 2	Depositor
Cell constants a, b, c, α , β , γ	93.20Å 93.20Å 122.19Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	30.67 – 2.50 30.67 – 2.50	Depositor EDS
% Data completeness (in resolution range)	(Not available) (30.67-2.50) 99.1 (30.67-2.50)	Depositor EDS
R_{merge}	0.05	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	6.34 (at 2.51Å)	Xtriage
Refinement program	CNS 1.1	Depositor
R, R_{free}	0.226 , 0.249 0.235 , 0.240	Depositor DCC
R_{free} test set	906 reflections (8.03%)	wwPDB-VP
Wilson B-factor (Å ²)	57.9	Xtriage
Anisotropy	0.355	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.41 , 86.5	EDS
L-test for twinning ²	$\langle L \rangle = 0.39$, $\langle L^2 \rangle = 0.23$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	1334	wwPDB-VP
Average B, all atoms (Å ²)	60.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.05% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

²Theoretical 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: SO4, NCO, PDI, A2M

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	0.51	1/290 (0.3%)	1.10	5/449 (1.1%)
2	B	0.40	0/297	0.63	0/464
3	C	0.39	0/414	0.59	0/645
4	D	0.38	0/416	1.02	1/643 (0.2%)
All	All	0.42	1/1417 (0.1%)	0.86	6/2201 (0.3%)

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	5	A2M	O3'-P	5.36	1.61	1.56

All (6) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	2	C	C4'-C3'-O3'	7.76	124.64	113.00
4	D	41	U	C2'-C3'-O3'	7.69	121.03	109.50
1	A	2	C	C4'-C3'-C2'	6.13	108.73	102.60
1	A	3	C	C4'-C3'-C2'	5.31	107.91	102.60
1	A	3	C	C4'-C3'-O3'	5.27	120.91	113.00
1	A	4	C	C2'-C3'-O3'	5.12	121.38	113.70

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	285	0	156	9	0
2	B	264	0	133	3	0
3	C	368	0	189	1	0
4	D	383	0	200	12	0
5	A	5	0	0	0	0
6	B	7	0	0	0	0
6	D	14	0	0	2	0
7	B	2	0	0	0	0
7	C	3	0	0	0	0
7	D	3	0	0	0	0
All	All	1334	0	678	24	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 12.

All (24) 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:2:C:O2'	1:A:3:C:H5'	1.75	0.87
2:B:3:G:O2'	2:B:4:G:H5'	1.88	0.73
1:A:1[B]:U:H2'	1:A:2:C:H5'	1.75	0.69
4:D:38:A:OP2	4:D:39:PDI:HG2	1.96	0.65
4:D:31:U:H2'	4:D:32:C:C6	2.35	0.61
4:D:40:A:OP1	6:D:101:NCO:N4	2.37	0.57
1:A:6:G:N7	4:D:38:A:H2'	2.23	0.53
1:A:1[B]:U:C2'	1:A:2:C:H5'	2.38	0.53
4:D:33:G:H2'	4:D:34:U:C6	2.45	0.51
4:D:33:G:H2'	4:D:34:U:H6	1.78	0.49
4:D:45:C:O2'	4:D:46:U:H5'	2.13	0.48
4:D:31:U:H2'	4:D:32:C:H6	1.77	0.47
1:A:1[B]:U:H2'	1:A:2:C:C5'	2.42	0.47
4:D:41:U:O2'	4:D:42:U:H2'	2.15	0.47
1:A:4:C:H5'	1:A:5:A2M:OP2	2.15	0.46
2:B:7:A:H2'	2:B:8:G:O4'	2.15	0.46
3:C:16:G:H2'	3:C:17:C:C6	2.51	0.45
4:D:47:G:O2'	4:D:48:C:H5'	2.18	0.44
2:B:10:A:H2'	2:B:11:G:C8	2.53	0.44
1:A:1[B]:U:O2	1:A:1[B]:U:O5'	2.24	0.43
4:D:40:A:OP1	6:D:101:NCO:N1	2.51	0.43
4:D:38:A:P	4:D:39:PDI:HG2	2.60	0.41

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:1[B]:U:O2	1:A:1[B]:U:O4'	2.37	0.41
1:A:6:G:N3	1:A:6:G:H2'	2.35	0.41

There are no symmetry-related clashes.

5.3 Torsion angles [i](#)

5.3.1 Protein backbone [i](#)

There are no protein molecules in this entry.

5.3.2 Protein sidechains [i](#)

There are no protein molecules in this entry.

5.3.3 RNA [i](#)

Mol	Chain	Analysed	Backbone Outliers	Pucker Outliers
1	A	12/13 (92%)	1 (8%)	0
2	B	11/12 (91%)	0	0
3	C	16/17 (94%)	1 (6%)	0
4	D	16/19 (84%)	2 (12%)	0
All	All	55/61 (90%)	4 (7%)	0

All (4) RNA backbone outliers are listed below:

Mol	Chain	Res	Type
1	A	6	G
3	C	22	A
4	D	38	A
4	D	42	U

There are no RNA pucker outliers to report.

5.4 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 (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	$\# Z > 2$
1	A2M	A	5	1,2	22,25,26	0.49	0	30,36,39	1.15	2 (6%)

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	A2M	A	5	1,2	-	0/9/27/28	0/3/3/3

There are no bond length outliers.

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	5	A2M	C2'-C1'-N9	3.91	120.19	113.75
1	A	5	A2M	O3'-C3'-C2'	2.60	118.46	111.19

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
1	A	5	A2M	1	0

5.5 Carbohydrates

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

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	$\# Z > 2$
6	NCO	B	102	-	6,6,6	1.00	0	-		
6	NCO	D	103	-	6,6,6	1.34	1 (16%)	-		
6	NCO	D	101	-	6,6,6	0.90	0	-		
5	SO4	A	201	-	4,4,4	0.47	0	6,6,6	0.06	0

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
6	D	103	NCO	CO-N1	2.06	2.03	1.96

There are no bond angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

1 monomer is involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
6	D	101	NCO	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, 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	12/13 (92%)	0.71	1 (8%) 17 15	28, 60, 92, 94	1 (8%)
2	B	12/12 (100%)	0.26	0 100 100	45, 62, 89, 91	0
3	C	17/17 (100%)	0.12	0 100 100	47, 53, 61, 62	0
4	D	18/19 (94%)	0.25	2 (11%) 10 8	45, 56, 68, 88	0
All	All	59/61 (96%)	0.31	3 (5%) 33 29	28, 56, 89, 94	1 (1%)

All (3) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
4	D	37	U	2.5
4	D	38	A	2.4
1	A	1[A]	U	2.2

6.2 Non-standard residues in protein, DNA, RNA chains [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
1	A2M	A	5	23/24	0.95	0.10	44,48,51,57	0

6.3 Carbohydrates [i](#)

There are no oligosaccharides 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
6	NCO	D	103	7/7	0.63	0.28	94,95,96,96	0
5	SO4	A	201	5/5	0.92	0.16	76,78,80,82	0
6	NCO	B	102	7/7	0.93	0.30	31,35,39,42	0
6	NCO	D	101	7/7	0.97	0.24	27,39,41,42	0

6.5 Other polymers [i](#)

There are no such residues in this entry.