



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 9, 2026 – 11:55 PM UTC

PDB ID : 7RAO / pdb_00007rao
Title : Structure of M66I mutant of disulfide stabilized HIV-1 CA hexamer
Authors : Bester, S.M.; Kvaratskhelia, M.
Deposited on : 2021-07-02
Resolution : 2.29 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
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

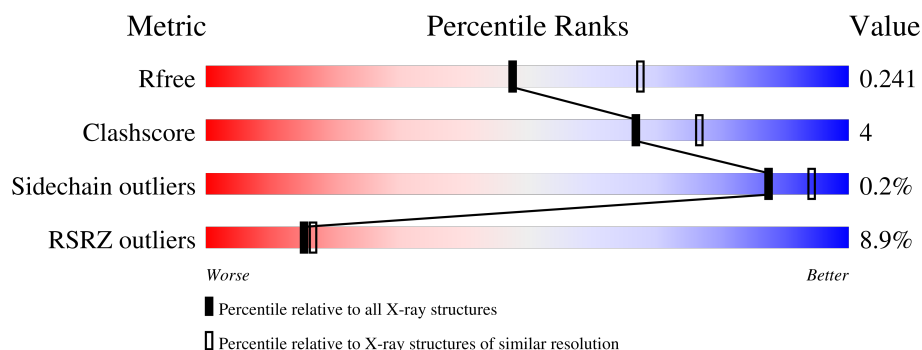
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.29 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	6319 (2.30-2.30)
Clashscore	190562	6919 (2.30-2.30)
Sidechain outliers	187428	6854 (2.30-2.30)
RSRZ outliers	180081	6325 (2.30-2.30)

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	231	8% 86% 9% 5%
1	B	231	6% 82% 9% 9%
1	C	231	10% 86% 6% 8%

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 5390 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 Capsid protein p24.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	219	Total	C	N	O	S	0	1	0
			1699	1070	300	316	13			
1	B	211	Total	C	N	O	S	0	0	0
			1641	1035	287	306	13			
1	C	213	Total	C	N	O	S	0	0	0
			1651	1041	289	308	13			

There are 15 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	14	CYS	ALA	engineered mutation	UNP P12493
A	45	CYS	GLU	engineered mutation	UNP P12493
A	66	ILE	MET	engineered mutation	UNP P12493
A	184	ALA	TRP	engineered mutation	UNP P12493
A	185	ALA	MET	engineered mutation	UNP P12493
B	14	CYS	ALA	engineered mutation	UNP P12493
B	45	CYS	GLU	engineered mutation	UNP P12493
B	66	ILE	MET	engineered mutation	UNP P12493
B	184	ALA	TRP	engineered mutation	UNP P12493
B	185	ALA	MET	engineered mutation	UNP P12493
C	14	CYS	ALA	engineered mutation	UNP P12493
C	45	CYS	GLU	engineered mutation	UNP P12493
C	66	ILE	MET	engineered mutation	UNP P12493
C	184	ALA	TRP	engineered mutation	UNP P12493
C	185	ALA	MET	engineered mutation	UNP P12493

- Molecule 2 is IODIDE ION (CCD ID: IOD) (formula: I).

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	A	3	Total I 3 3	0	0

Continued on next page...

Continued from previous page...

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	B	3	Total I 3 3	0	0
2	C	4	Total I 4 4	0	0

- Molecule 3 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	4	Total Cl 4 4	0	0
3	B	3	Total Cl 3 3	0	0
3	C	5	Total Cl 5 5	0	0

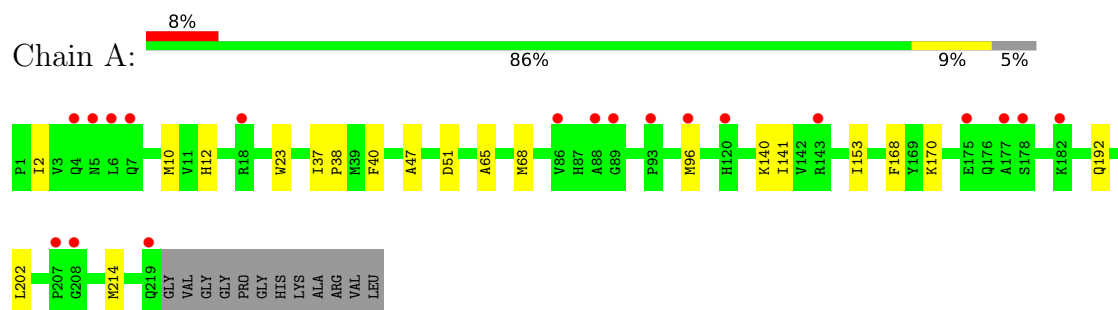
- Molecule 4 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	A	112	Total O 112 112	0	0
4	B	112	Total O 112 112	0	0
4	C	153	Total O 153 153	0	0

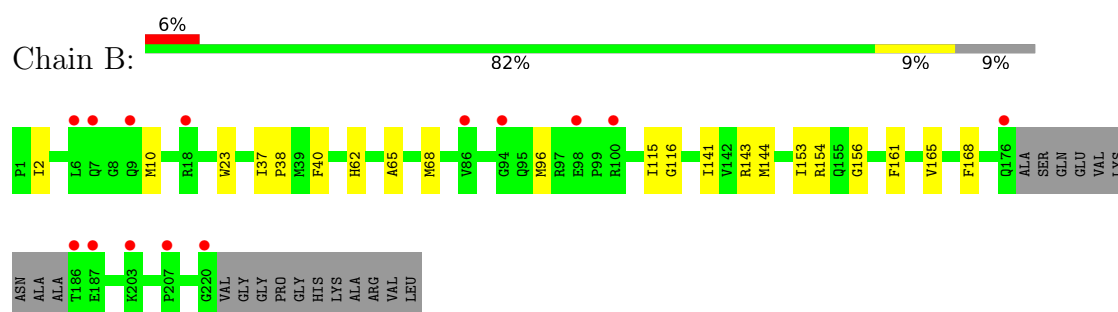
3 Residue-property plots [i](#)

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.

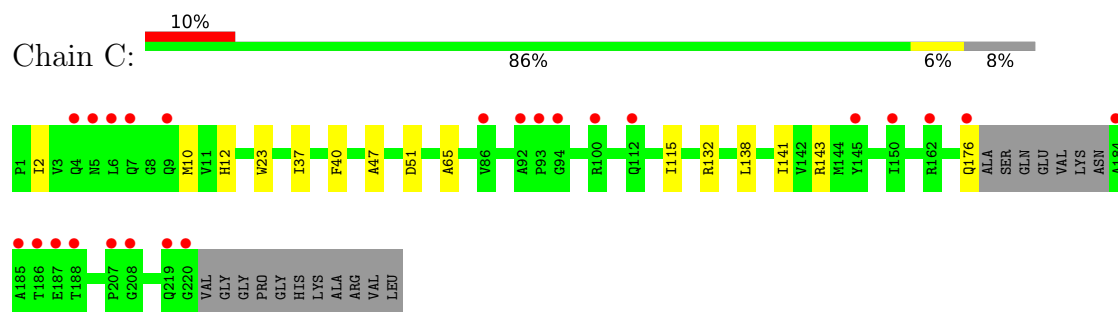
• Molecule 1: Capsid protein p24



• Molecule 1: Capsid protein p24



• Molecule 1: Capsid protein p24



4 Data and refinement statistics

Property	Value	Source
Space group	P 6	Depositor
Cell constants a, b, c, α , β , γ	158.96Å 158.96Å 57.71Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	44.22 – 2.29 44.22 – 2.29	Depositor EDS
% Data completeness (in resolution range)	99.6 (44.22-2.29) 99.7 (44.22-2.29)	Depositor EDS
R_{merge}	0.04	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.46 (at 2.29Å)	Xtriage
Refinement program	PHENIX 1.18.2_3874	Depositor
R, R_{free}	0.215 , 0.244 0.218 , 0.241	Depositor DCC
R_{free} test set	1898 reflections (5.02%)	wwPDB-VP
Wilson B-factor (Å ²)	31.8	Xtriage
Anisotropy	0.184	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.35 , 45.0	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.34$	Xtriage
Estimated twinning fraction	0.032 for h,-h-k,-l	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	5390	wwPDB-VP
Average B, all atoms (Å ²)	38.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 43.42 % of the origin peak, indicating pseudo-translational symmetry. The chance of finding a peak of this or larger height randomly in a structure without pseudo-translational symmetry is equal to 1.7689e-04. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

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 [i](#)

5.1 Standard geometry [i](#)

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

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	0.09	0/1736	0.26	0/2361
1	B	0.10	0/1677	0.27	0/2279
1	C	0.10	0/1687	0.27	0/2293
All	All	0.10	0/5100	0.27	0/6933

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 [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	1699	0	1701	12	0
1	B	1641	0	1645	15	0
1	C	1651	0	1655	9	0
2	A	3	0	0	0	0
2	B	3	0	0	1	0
2	C	4	0	0	0	0
3	A	4	0	0	0	0
3	B	3	0	0	0	0
3	C	5	0	0	1	0
4	A	112	0	0	2	0

Continued on next page...

Continued from previous page...

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
4	B	112	0	0	3	0
4	C	153	0	0	2	0
All	All	5390	0	5001	37	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 4.

All (37) 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)
3:C:305:CL:CL	4:C:503:HOH:O	2.40	0.75
1:A:202:LEU:HD13	1:A:214:MET:HE3	1.81	0.60
1:B:62:HIS:ND1	4:B:402:HOH:O	2.33	0.57
1:B:2:ILE:HD11	1:B:115:ILE:HG12	1.86	0.57
1:C:2:ILE:HD11	1:C:115:ILE:HG12	1.90	0.53
1:B:2:ILE:HG22	1:B:10:MET:HE3	1.90	0.53
1:C:65:ALA:HB1	1:C:141:ILE:HD13	1.92	0.51
1:C:143:ARG:HD3	1:C:176:GLN:HB2	1.93	0.51
1:B:153:ILE:HG21	1:B:168:PHE:HA	1.93	0.51
1:C:132:ARG:NH2	4:C:404:HOH:O	2.44	0.50
1:C:2:ILE:HG22	1:C:10:MET:HE3	1.92	0.50
1:A:68:MET:HE3	1:A:141:ILE:HG12	1.95	0.48
1:A:140:LYS:NZ	4:A:405:HOH:O	2.44	0.48
1:B:156:GLY:HA3	2:B:301:IOD:I	2.84	0.48
1:A:2:ILE:HG22	1:A:10:MET:HE3	1.94	0.48
1:B:65:ALA:HB1	1:B:141:ILE:HD13	1.96	0.47
1:B:143:ARG:NH2	4:B:407:HOH:O	2.46	0.47
1:A:170:LYS:NZ	4:A:406:HOH:O	2.47	0.47
1:B:96:MET:SD	1:B:116:GLY:HA3	2.55	0.47
1:A:153:ILE:HG21	1:A:168:PHE:HA	1.99	0.44
1:A:192:GLN:OE1	1:A:192:GLN:N	2.46	0.44
1:B:154:ARG:NH2	4:B:403:HOH:O	2.35	0.44
1:A:2:ILE:HD13	1:A:12:HIS:HA	2.00	0.43
1:C:37:ILE:HD12	1:C:138:LEU:HB3	2.00	0.43
1:A:37:ILE:HB	1:A:38:PRO:HD3	2.00	0.43
1:B:144:MET:HE3	1:B:144:MET:HB2	1.89	0.43
1:A:23:TRP:CZ3	1:A:40:PHE:HB2	2.54	0.43
1:A:65:ALA:HB1	1:A:141:ILE:HD13	2.01	0.42
1:B:37:ILE:HB	1:B:38:PRO:HD3	2.02	0.42
1:B:68:MET:HE3	1:B:141:ILE:HG12	2.02	0.42
1:B:23:TRP:CZ3	1:B:40:PHE:HB2	2.55	0.41

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:C:47:ALA:HB1	1:C:51:ASP:HB2	2.03	0.41
1:A:47:ALA:HB1	1:A:51:ASP:HB2	2.03	0.41
1:C:23:TRP:CZ3	1:C:40:PHE:HB2	2.56	0.41
1:C:2:ILE:HD13	1:C:12:HIS:HA	2.03	0.41
1:B:161:PHE:O	1:B:165:VAL:HG23	2.21	0.40
1:B:96:MET:HB3	1:B:96:MET:HE2	1.79	0.40

There are no symmetry-related clashes.

5.3 Torsion angles [i](#)

5.3.1 Protein backbone [i](#)

There are no protein backbone outliers to report in this entry.

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	184/193 (95%)	183 (100%)	1 (0%)	81	90
1	B	180/193 (93%)	180 (100%)	0	100	100
1	C	180/193 (93%)	180 (100%)	0	100	100
All	All	544/579 (94%)	543 (100%)	1 (0%)	87	94

All (1) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	96	MET

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (12) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	21	ASN
1	A	62	HIS
1	A	84	HIS
1	A	95	GLN
1	A	176	GLN
1	B	7	GLN
1	B	62	HIS
1	B	95	GLN
1	B	192	GLN
1	C	21	ASN
1	C	62	HIS
1	C	84	HIS

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 oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

Of 22 ligands modelled in this entry, 22 are monoatomic - leaving 0 for Mogul analysis.

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

No monomer is involved in short contacts.

5.7 Other polymers [i](#)

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	219/231 (94%)	0.48	19 (8%)	16	17	16, 35, 70, 91	1 (0%)
1	B	211/231 (91%)	0.45	14 (6%)	24	26	21, 35, 72, 91	0
1	C	213/231 (92%)	0.74	24 (11%)	10	11	23, 35, 67, 111	0
All	All	643/693 (92%)	0.56	57 (8%)	15	17	16, 35, 70, 111	1 (0%)

All (57) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	C	220	GLY	6.2
1	B	186	THR	5.4
1	C	184	ALA	5.3
1	C	7	GLN	4.7
1	C	185	ALA	4.5
1	B	220	GLY	4.3
1	C	6	LEU	4.1
1	A	175	GLU	4.1
1	B	86	VAL	4.1
1	A	219	GLN	4.0
1	B	7	GLN	3.9
1	C	188	THR	3.9
1	B	6	LEU	3.8
1	C	186	THR	3.7
1	A	6	LEU	3.6
1	A	86	VAL	3.5
1	C	9	GLN	3.4
1	B	187	GLU	3.4
1	C	100	ARG	3.2
1	C	86	VAL	2.9
1	C	207	PRO	2.9
1	A	88	ALA	2.8
1	B	18	ARG	2.7

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type	RSRZ
1	A	207	PRO	2.7
1	B	176	GLN	2.7
1	A	178	SER	2.6
1	A	120	HIS	2.6
1	A	177	ALA	2.5
1	C	187	GLU	2.5
1	C	162	ARG	2.5
1	C	5	ASN	2.5
1	C	208	GLY	2.5
1	C	145	TYR	2.4
1	A	89	GLY	2.4
1	A	208	GLY	2.3
1	B	100	ARG	2.3
1	A	7	GLN	2.3
1	B	9	GLN	2.3
1	A	93	PRO	2.3
1	B	98	GLU	2.3
1	C	94	GLY	2.3
1	A	5	ASN	2.3
1	A	143	ARG	2.3
1	C	150	ILE	2.2
1	B	94	GLY	2.2
1	C	93	PRO	2.2
1	C	176	GLN	2.2
1	C	219	GLN	2.2
1	B	203	LYS	2.1
1	B	207	PRO	2.1
1	C	112	GLN	2.1
1	A	18	ARG	2.1
1	C	92	ALA	2.1
1	A	182	LYS	2.1
1	A	96	MET	2.0
1	A	4	GLN	2.0
1	C	4	GLN	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 [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($\text{\AA}^2$)	Q<0.9
2	IOD	C	302	1/1	0.85	0.46	144,144,144,144	0
2	IOD	C	303	1/1	0.90	0.24	141,141,141,141	0
3	CL	A	307	1/1	0.90	0.12	28,28,28,28	0
3	CL	C	308	1/1	0.91	0.20	55,55,55,55	0
2	IOD	A	302	1/1	0.96	0.16	106,106,106,106	0
3	CL	B	303	1/1	0.97	0.08	37,37,37,37	0
3	CL	B	305	1/1	0.97	0.12	28,28,28,28	0
3	CL	A	304	1/1	0.97	0.06	46,46,46,46	0
3	CL	C	309	1/1	0.97	0.15	45,45,45,45	0
2	IOD	B	302	1/1	0.98	0.14	77,77,77,77	0
2	IOD	C	301	1/1	0.98	0.03	38,38,38,38	0
3	CL	C	305	1/1	0.98	0.06	46,46,46,46	0
3	CL	C	307	1/1	0.98	0.19	13,13,13,13	0
3	CL	A	305	1/1	0.98	0.18	21,21,21,21	0
2	IOD	B	301	1/1	0.98	0.05	41,41,41,41	0
3	CL	C	306	1/1	0.99	0.06	28,28,28,28	0
3	CL	B	304	1/1	0.99	0.17	12,12,12,12	0
2	IOD	A	301	1/1	0.99	0.04	40,40,40,40	0
3	CL	A	306	1/1	0.99	0.08	25,25,25,25	0
2	IOD	B	306	1/1	1.00	0.09	44,44,44,44	0
2	IOD	A	303	1/1	1.00	0.03	34,34,34,34	0
2	IOD	C	304	1/1	1.00	0.06	35,35,35,35	0

6.5 Other polymers [i](#)

There are no such residues in this entry.