



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 5, 2026 – 07:59 AM UTC

PDB ID : 5X5A / pdb_00005x5a
Title : Human thymidylate synthase bound with phosphate ion
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Deposited on : 2017-02-15
Resolution : 2.39 Å(reported)

This is a wwPDB X-ray Structure Validation Summary 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

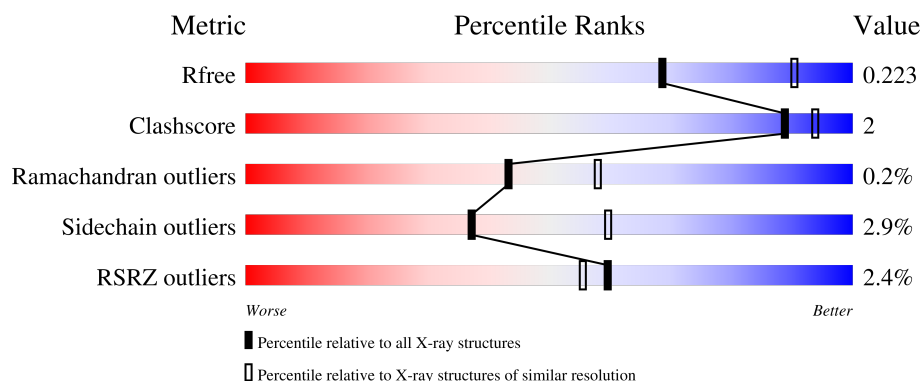
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.39 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.



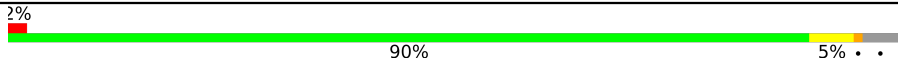
Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	180053	4912 (2.40-2.40)
Clashscore	190562	5391 (2.40-2.40)
Ramachandran outliers	187476	5320 (2.40-2.40)
Sidechain outliers	187428	5321 (2.40-2.40)
RSRZ outliers	180081	4916 (2.40-2.40)

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	290	3% 92% 6% ..
1	B	290	2% 91% 7% ..
1	C	290	2% 91% .. .
1	D	290	2% 89% 6% . .
1	E	290	3% 87% 7% . .

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Mol	Chain	Length	Quality of chain
1	F	290	 A horizontal bar chart showing the quality of chain 1. The bar is green, indicating a high quality. The chart is labeled with '2%' at the start, '90%' in the middle, and '5%' at the end. There are two small dots at the end of the bar.

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
2	PO4	D	401	-	-	X	-

2 Entry composition

There are 3 unique types of molecules in this entry. The entry contains 13841 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.

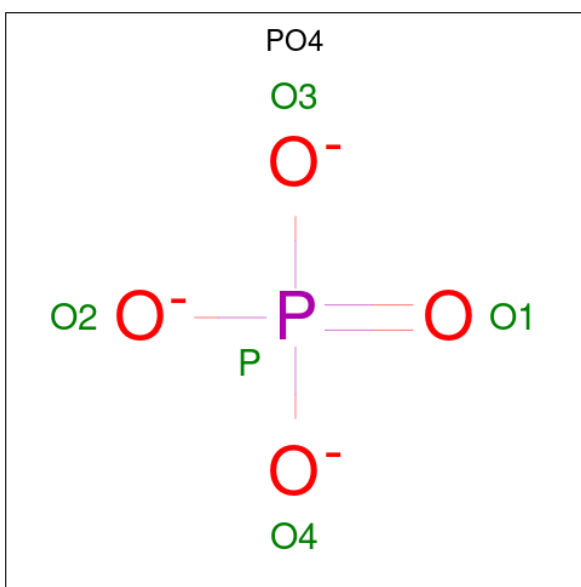
- Molecule 1 is a protein called Thymidylate synthase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	287	Total	C	N	O	S	0	0	0
			2299	1469	403	415	12			
1	B	287	Total	C	N	O	S	0	0	0
			2303	1473	400	417	13			
1	C	281	Total	C	N	O	S	0	0	0
			2264	1448	394	411	11			
1	D	279	Total	C	N	O	S	0	1	0
			2240	1434	386	409	11			
1	E	279	Total	C	N	O	S	0	0	0
			2236	1431	385	409	11			
1	F	279	Total	C	N	O	S	0	0	0
			2236	1430	387	408	11			

There are 12 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	24	SER	-	expression tag	UNP P04818
A	25	MET	-	expression tag	UNP P04818
B	24	SER	-	expression tag	UNP P04818
B	25	MET	-	expression tag	UNP P04818
C	24	SER	-	expression tag	UNP P04818
C	25	MET	-	expression tag	UNP P04818
D	24	SER	-	expression tag	UNP P04818
D	25	MET	-	expression tag	UNP P04818
E	24	SER	-	expression tag	UNP P04818
E	25	MET	-	expression tag	UNP P04818
F	24	SER	-	expression tag	UNP P04818
F	25	MET	-	expression tag	UNP P04818

- Molecule 2 is PHOSPHATE ION (CCD ID: PO4) (formula: O₄P).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	O	P	0	0
			5	4	1		
2	B	1	Total	O	P	0	0
			5	4	1		
2	C	1	Total	O	P	0	0
			5	4	1		
2	D	1	Total	O	P	0	0
			5	4	1		
2	E	1	Total	O	P	0	0
			5	4	1		
2	F	1	Total	O	P	0	0
			5	4	1		

- Molecule 3 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	44	Total	O	0	0
			44	44		
3	B	44	Total	O	0	0
			44	44		
3	C	31	Total	O	0	0
			31	31		
3	D	38	Total	O	0	0
			38	38		
3	E	42	Total	O	0	0
			42	42		
3	F	34	Total	O	0	0
			34	34		

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: Thymidylate synthase



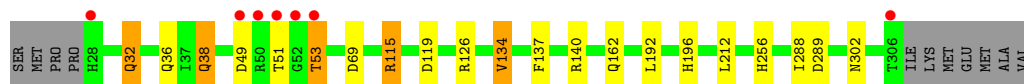
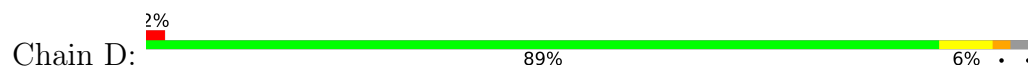
- Molecule 1: Thymidylate synthase



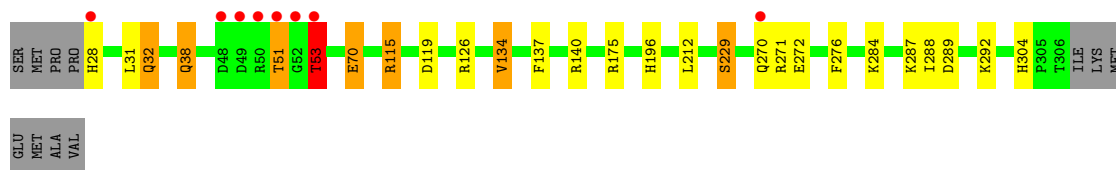
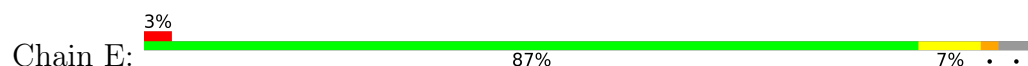
- Molecule 1: Thymidylate synthase



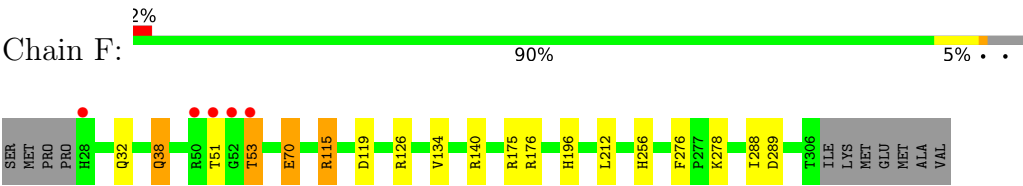
- Molecule 1: Thymidylate synthase



- Molecule 1: Thymidylate synthase



● Molecule 1: Thymidylate synthase



4 Data and refinement statistics

Property	Value	Source
Space group	P 43 21 2	Depositor
Cell constants a, b, c, α , β , γ	109.53Å 109.53Å 317.47Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	20.35 – 2.39 20.35 – 2.39	Depositor EDS
% Data completeness (in resolution range)	85.1 (20.35-2.39) 85.1 (20.35-2.39)	Depositor EDS
R_{merge}	0.10	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.35 (at 2.38Å)	Xtriage
Refinement program	REFMAC 5.8.0155	Depositor
R, R_{free}	0.217 , 0.251 (Not available) , 0.223	Depositor DCC
R_{free} test set	3230 reflections (4.19%)	wwPDB-VP
Wilson B-factor (Å ²)	35.6	Xtriage
Anisotropy	0.072	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.34 , 21.7	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	13841	wwPDB-VP
Average B, all atoms (Å ²)	37.0	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 53.64 % 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 4.0943e-05. 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 ⓘ

5.1 Standard geometry ⓘ

Bond lengths and bond angles in the following residue types are not validated in this section: PO4

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	1.03	3/2359 (0.1%)	1.04	3/3193 (0.1%)
1	B	1.01	3/2363 (0.1%)	1.06	1/3198 (0.0%)
1	C	0.95	2/2324 (0.1%)	1.05	1/3146 (0.0%)
1	D	0.99	3/2297 (0.1%)	1.04	3/3110 (0.1%)
1	E	1.01	4/2294 (0.2%)	1.04	4/3107 (0.1%)
1	F	0.95	1/2293 (0.0%)	1.05	3/3105 (0.1%)
All	All	0.99	16/13930 (0.1%)	1.05	15/18859 (0.1%)

The worst 5 of 16 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	B	137	PHE	C-O	-6.81	1.16	1.24
1	D	137	PHE	C-O	-6.67	1.16	1.24
1	A	137	PHE	C-O	-6.33	1.16	1.24
1	C	211	GLN	C-O	-6.25	1.16	1.24
1	D	134	VAL	C-O	-6.05	1.16	1.24

The worst 5 of 15 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	C	163	ARG	CB-CG-CD	9.87	134.00	111.30
1	D	256	HIS	N-CA-C	7.02	120.59	109.50
1	F	256	HIS	N-CA-C	6.68	119.58	109.23
1	E	284	LYS	CB-CG-CD	5.93	124.94	111.30
1	E	70	GLU	CA-CB-CG	5.90	125.91	114.10

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	2299	0	2253	6	0
1	B	2303	0	2262	8	0
1	C	2264	0	2224	11	0
1	D	2240	0	2185	7	0
1	E	2236	0	2180	11	0
1	F	2236	0	2182	8	0
2	A	5	0	0	0	0
2	B	5	0	0	0	0
2	C	5	0	0	1	0
2	D	5	0	0	2	0
2	E	5	0	0	1	0
2	F	5	0	0	0	0
3	A	44	0	0	0	0
3	B	44	0	0	0	0
3	C	31	0	0	0	0
3	D	38	0	0	0	0
3	E	42	0	0	1	0
3	F	34	0	0	0	0
All	All	13841	0	13286	50	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.

The worst 5 of 50 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:C:192:LEU:HD12	1:C:192:LEU:O	1.80	0.81
2:C:401:PO4:O4	1:F:176:ARG:NE	2.15	0.78
1:E:28:HIS:HB2	1:E:31:LEU:HD12	1.68	0.75
1:B:196:HIS:HB3	1:B:212:LEU:HD11	1.75	0.67
1:A:196:HIS:HB3	1:A:212:LEU:HD11	1.78	0.64

There are no symmetry-related clashes.

5.3 Torsion angles ⓘ

5.3.1 Protein backbone ⓘ

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	285/290 (98%)	274 (96%)	10 (4%)	1 (0%)	30	43
1	B	285/290 (98%)	275 (96%)	10 (4%)	0	100	100
1	C	279/290 (96%)	268 (96%)	11 (4%)	0	100	100
1	D	278/290 (96%)	269 (97%)	8 (3%)	1 (0%)	30	43
1	E	277/290 (96%)	266 (96%)	10 (4%)	1 (0%)	30	43
1	F	277/290 (96%)	267 (96%)	10 (4%)	0	100	100
All	All	1681/1740 (97%)	1619 (96%)	59 (4%)	3 (0%)	43	58

All (3) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	E	134	VAL
1	D	134	VAL
1	A	134	VAL

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	245/253 (97%)	238 (97%)	7 (3%)	37	60
1	B	247/253 (98%)	238 (96%)	9 (4%)	31	52
1	C	244/253 (96%)	240 (98%)	4 (2%)	55	76
1	D	238/253 (94%)	231 (97%)	7 (3%)	37	60

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	E	239/253 (94%)	230 (96%)	9 (4%)	29	49
1	F	238/253 (94%)	232 (98%)	6 (2%)	42	64
All	All	1451/1518 (96%)	1409 (97%)	42 (3%)	37	60

5 of 42 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	E	38	GLN
1	E	288	ILE
1	E	51	THR
1	E	229	SER
1	F	38	GLN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 7 such sidechains are listed below:

Mol	Chain	Res	Type
1	D	162	GLN
1	E	162	GLN
1	F	256	HIS
1	F	196	HIS
1	C	196	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](#)

6 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	$\# Z > 2$
2	PO4	A	401	-	4,4,4	0.96	0	6,6,6	0.46	0
2	PO4	C	401	-	4,4,4	0.97	0	6,6,6	0.46	0
2	PO4	D	401	-	4,4,4	0.96	0	6,6,6	0.47	0
2	PO4	E	401	-	4,4,4	0.96	0	6,6,6	0.46	0
2	PO4	B	401	-	4,4,4	0.96	0	6,6,6	0.46	0
2	PO4	F	401	-	4,4,4	0.97	0	6,6,6	0.47	0

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.

3 monomers are involved in 4 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	C	401	PO4	1	0
2	D	401	PO4	2	0
2	E	401	PO4	1	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	287/290 (98%)	-0.22	8 (2%) 55 51	19, 33, 56, 100	0
1	B	287/290 (98%)	-0.05	6 (2%) 63 59	22, 36, 63, 85	0
1	C	281/290 (96%)	-0.02	6 (2%) 63 59	22, 37, 59, 104	0
1	D	279/290 (96%)	-0.23	7 (2%) 58 54	14, 32, 55, 94	1 (0%)
1	E	279/290 (96%)	-0.11	8 (2%) 53 50	21, 34, 57, 91	0
1	F	279/290 (96%)	-0.15	5 (1%) 67 63	22, 36, 57, 88	0
All	All	1692/1740 (97%)	-0.13	40 (2%) 59 55	14, 35, 59, 104	1 (0%)

The worst 5 of 40 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	F	28	HIS	4.8
1	A	52	GLY	4.5
1	A	307	ILE	4.1
1	E	53	THR	4.0
1	C	26	PRO	3.8

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

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(Å ²)	Q<0.9
2	PO4	E	401	5/5	0.94	0.10	41,43,45,51	0
2	PO4	B	401	5/5	0.95	0.10	40,42,46,51	0
2	PO4	D	401	5/5	0.96	0.05	42,43,47,49	0
2	PO4	C	401	5/5	0.96	0.07	44,46,47,49	0
2	PO4	A	401	5/5	0.97	0.07	39,40,41,43	0
2	PO4	F	401	5/5	0.97	0.06	37,41,45,49	0

6.5 Other polymers [i](#)

There are no such residues in this entry.