wwPDB X-ray Structure Validation Summary Report (i)

Feb 1, 2016 – 02:30 PM GMT

PDB ID	:	3ZOO
Title	:	Structure of the Y46F mutant of human cytochrome c
Authors	:	Rajagopal, B.S.; Worrall, J.A.R.; Hough, M.A.
Deposited on	:	2013-02-22
Resolution	:	1.35 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
http://wwpdb.org/validation/2016/XrayValidationReportHelp
with specific help available everywhere you see the (i) symbol.

The following versions of software and data (see references (1)) were used in the production of this report:

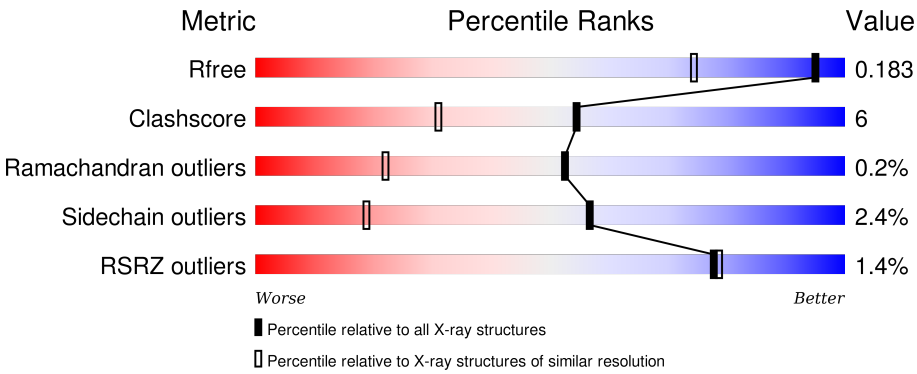
MolProbity	:	4.02b-467
Mogul	:	1.7 (RC4), CSD as536be (2015)
Xtriage (Phenix)	:	1.9-1692
EDS	:	rb-20026688
Percentile statistics	:	20151230.v01 (using entries in the PDB archive December 30th 2015)
Refmac	:	5.8.0135
CCP4	:	6.5.0
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	trunk26865

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 1.35 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}	91344	2199 (1.40-1.32)
Clashscore	102246	2337 (1.40-1.32)
Ramachandran outliers	100387	2280 (1.40-1.32)
Sidechain outliers	100360	2279 (1.40-1.32)
RSRZ outliers	91569	2199 (1.40-1.32)

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 on the lower bar indicate the fraction of residues that contain outliers for >=3, 2, 1 and 0 types of geometric quality criteria. 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	104	88% 10% •
1	B	104	% 93% 6% •
1	C	104	3% 88% 9% • •
1	D	104	2% 90% 9% •

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
3	PO4	A	1105	-	-	-	X

2 Entry composition (i)

There are 4 unique types of molecules in this entry. The entry contains 3983 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.

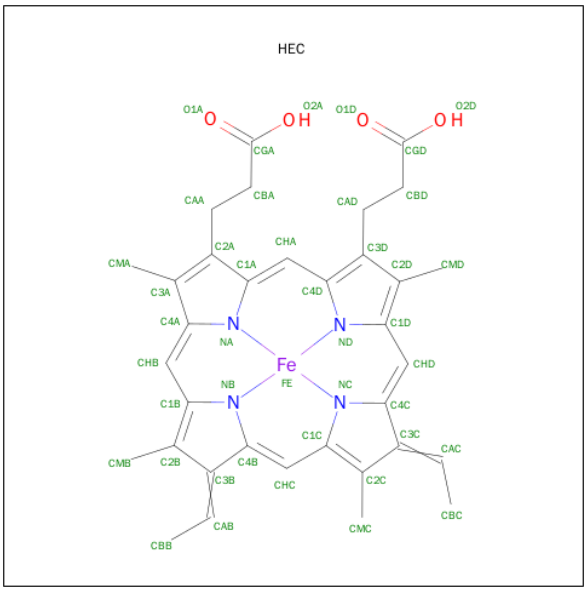
- Molecule 1 is a protein called CYTOCHROME C.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	104	848	542	148	153	5	22	5	0
1	B	104	836	537	145	149	5	11	4	0
1	C	104	858	549	150	153	6	19	8	0
1	D	104	840	536	145	153	6	16	4	0

There are 4 discrepancies between the modelled and reference sequences:

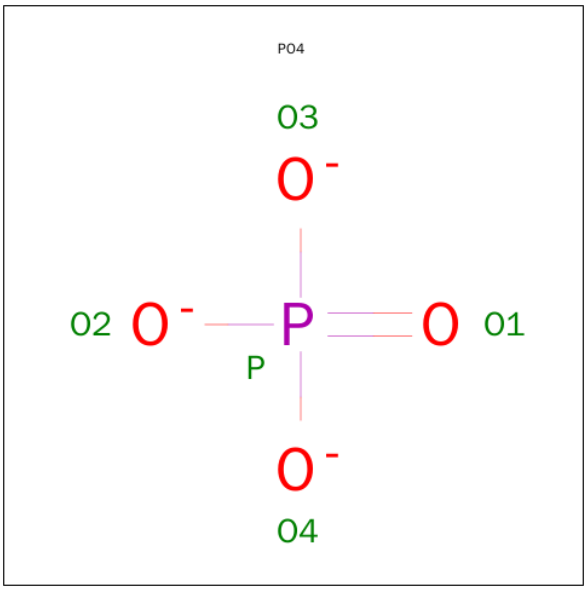
Chain	Residue	Modelled	Actual	Comment	Reference
A	46	PHE	TYR	ENGINEERED MUTATION	UNP P99999
B	46	PHE	TYR	ENGINEERED MUTATION	UNP P99999
C	46	PHE	TYR	ENGINEERED MUTATION	UNP P99999
D	46	PHE	TYR	ENGINEERED MUTATION	UNP P99999

- Molecule 2 is HEME C (three-letter code: HEC) (formula: $C_{34}H_{34}FeN_4O_4$).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
			Total	C	Fe	N	O		
2	A	1	43	34	1	4	4	0	0
			Total	C	Fe	N	O		
2	B	1	43	34	1	4	4	0	0
			Total	C	Fe	N	O		
2	C	1	43	34	1	4	4	0	0
			Total	C	Fe	N	O		
2	D	1	43	34	1	4	4	0	0

- Molecule 3 is PHOSPHATE ION (three-letter code: PO4) (formula: O_4P).



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

- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
			Total	O		
4	A	145	146	146	0	1
			Total	O		
4	B	88	88	88	0	0
			Total	O		
4	C	92	93	93	0	1
			Total	O		
4	D	92	92	92	0	0

3 Residue-property plots (i)

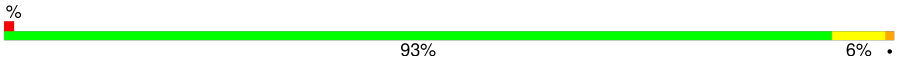
These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of errors displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. Residues are color-coded according 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.

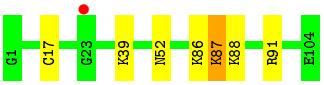
- Molecule 1: CYTOCHROME C

Chain A:

- Molecule 1: CYTOCHROME C

Chain B:





- Molecule 1: CYTOCHROME C

Chain C:

- Molecule 1: CYTOCHROME C

Chain D:

4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 1	Depositor
Cell constants a, b, c, α, β, γ	36.37Å 53.95Å 58.95Å 76.55° 88.73° 71.86°	Depositor
Resolution (Å)	30.59 – 1.35 30.57 – 1.35	Depositor EDS
% Data completeness (in resolution range)	94.7 (30.59-1.35) 88.7 (30.57-1.35)	Depositor EDS
R_{merge}	0.07	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	2.21 (at 1.35Å)	Xtriage
Refinement program	REFMAC 5.7.0029	Depositor
R, R_{free}	0.138 , 0.179 0.146 , 0.183	Depositor DCC
R_{free} test set	4340 reflections (5.31%)	DCC
Wilson B-factor (Å^2)	14.9	Xtriage
Anisotropy	0.456	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.36 , 55.9	EDS
Estimated twinning fraction	0.025 for h,h-k,-l	Xtriage
L-test for twinning[2]	$< \|L\| > = 0.48$, $< L^2 > = 0.31$	Xtriage
Outliers	0 of 86045 reflections	Xtriage
F_o,F_c correlation	0.98	EDS
Total number of atoms	3983	wwPDB-VP
Average B, all atoms (Å^2)	19.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 7.22% 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, 0.375 respectively for untwinned datasets, and 0.333, 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: PO4, HEC

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	0.85	3/870 (0.3%)	0.95	2/1153 (0.2%)
1	B	1.04	5/864 (0.6%)	1.18	4/1148 (0.3%)
1	C	0.88	2/890 (0.2%)	0.90	1/1185 (0.1%)
1	D	1.04	4/862 (0.5%)	1.02	7/1147 (0.6%)
All	All	0.96	14/3486 (0.4%)	1.02	14/4633 (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 outliers	#Planarity outliers
1	C	0	1

The worst 5 of 14 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	B	88	LYS	CD-CE	-12.78	1.19	1.51
1	B	87	LYS	CG-CD	-12.08	1.11	1.52
1	D	5	LYS	CE-NZ	-11.72	1.19	1.49
1	C	89	GLU	CB-CG	-9.87	1.33	1.52
1	D	39	LYS	CD-CE	-9.53	1.27	1.51

The worst 5 of 14 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	B	87	LYS	CB-CG-CD	20.03	163.69	111.60
1	B	87	LYS	CG-CD-CE	14.46	155.28	111.90
1	B	88	LYS	CD-CE-NZ	11.83	138.90	111.70
1	D	5	LYS	CD-CE-NZ	11.53	138.22	111.70

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	A	72	LYS	CD-CE-NZ	9.34	133.19	111.70

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	C	24[A]	GLY	Peptide

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	848	0	881	10	0
1	B	836	0	883	6	0
1	C	858	0	892	11	0
1	D	840	0	868	10	0
2	A	43	0	30	4	0
2	B	43	0	31	6	0
2	C	43	0	31	5	0
2	D	43	0	31	6	0
3	A	10	0	0	0	0
4	A	146	0	0	1	1
4	B	88	0	0	1	1
4	C	93	0	0	3	0
4	D	92	0	0	2	0
All	All	3983	0	3647	41	1

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.

The worst 5 of 41 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:D:17:CYS:SG	2:D:105:HEC:HAC	1.94	1.04
1:C:17:CYS:SG	2:C:105:HEC:HAC	2.10	0.91

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:17:CYS:SG	2:B:105:HEC:CBC	2.68	0.81
1:A:17:CYS:SG	2:A:105:HEC:C3C	2.71	0.79
1:D:17:CYS:SG	2:D:105:HEC:C3C	2.71	0.79

All (1) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
4:A:2141:HOH:O	4:B:2012:HOH:O[1_465]	2.13	0.07

5.3 Torsion angles (i)

5.3.1 Protein backbone (i)

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	106/104 (102%)	104 (98%)	2 (2%)	0	100 100
1	B	106/104 (102%)	103 (97%)	3 (3%)	0	100 100
1	C	110/104 (106%)	106 (96%)	3 (3%)	1 (1%)	21 4
1	D	106/104 (102%)	103 (97%)	3 (3%)	0	100 100
All	All	428/416 (103%)	416 (97%)	11 (3%)	1 (0%)	52 22

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	C	25	LYS

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	89/85 (105%)	87 (98%)	2 (2%)	60	22
1	B	89/85 (105%)	87 (98%)	2 (2%)	60	22
1	C	91/85 (107%)	86 (94%)	5 (6%)	27	3
1	D	89/85 (105%)	87 (98%)	2 (2%)	60	22
All	All	358/340 (105%)	347 (97%)	11 (3%)	57	11

5 of 11 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	C	21	GLU
1	C	25	LYS
1	C	52[B]	ASN
1	B	87	LYS
1	C	52[A]	ASN

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. There are no such sidechains identified.

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 carbohydrates 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	HEC	A	105	1	24,50,50	1.74	5 (20%)	19,82,82	2.56	10 (52%)
3	PO4	A	1105	-	4,4,4	0.53	0	6,6,6	0.30	0
3	PO4	A	1106	-	4,4,4	0.51	0	6,6,6	0.28	0
2	HEC	B	105	1	24,50,50	1.58	3 (12%)	19,82,82	2.49	7 (36%)
2	HEC	C	105	1	24,50,50	1.18	2 (8%)	19,82,82	2.67	10 (52%)
2	HEC	D	105	1	24,50,50	2.03	8 (33%)	19,82,82	2.29	8 (42%)

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
2	HEC	A	105	1	-	0/6/54/54	0/0/8/8
3	PO4	A	1105	-	-	0/0/0/0	0/0/0/0
3	PO4	A	1106	-	-	0/0/0/0	0/0/0/0
2	HEC	B	105	1	-	0/6/54/54	0/0/8/8
2	HEC	C	105	1	-	0/6/54/54	0/0/8/8
2	HEC	D	105	1	-	0/6/54/54	0/0/8/8

The worst 5 of 18 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	105	HEC	C3B-C2B	-5.34	1.35	1.40
2	A	105	HEC	C3C-C2C	-3.78	1.36	1.40
2	B	105	HEC	C3B-C2B	-3.78	1.36	1.40
2	B	105	HEC	CBC-CAC	-3.40	1.35	1.49
2	A	105	HEC	CBC-CAC	-3.30	1.36	1.49

The worst 5 of 35 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	B	105	HEC	CBB-CAB-C3B	-6.22	113.53	127.35
2	A	105	HEC	CBB-CAB-C3B	-5.92	114.20	127.35
2	C	105	HEC	CBB-CAB-C3B	-5.79	114.47	127.35
2	B	105	HEC	CMB-C2B-C1B	-4.08	121.61	128.36

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	D	105	HEC	CBB-CAB-C3B	-4.08	118.29	127.35

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

4 monomers are involved in 21 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	105	HEC	4	0
2	B	105	HEC	6	0
2	C	105	HEC	5	0
2	D	105	HEC	6	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	104/104 (100%)	-0.08	0	100	100	9, 15, 24, 28	13 (12%)
1	B	104/104 (100%)	-0.20	1 (0%)	84	85	11, 17, 26, 43	10 (9%)
1	C	104/104 (100%)	0.16	3 (2%)	55	57	10, 20, 43, 62	13 (12%)
1	D	104/104 (100%)	-0.18	2 (1%)	70	71	9, 16, 29, 46	14 (13%)
All	All	416/416 (100%)	-0.08	6 (1%)	78	78	9, 17, 29, 62	50 (12%)

The worst 5 of 6 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	C	44	PRO	4.3
1	C	23	GLY	3.4
1	C	43	ALA	3.0
1	B	23	GLY	2.6
1	D	23	GLY	2.4

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 carbohydrates 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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. 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	LLDF	B-factors(Å^2)	Q<0.9
3	PO4	A	1105	5/5	0.96	0.10	3.02	15,16,20,26	5
2	HEC	D	105	43/43	0.99	0.07	0.14	6,8,11,15	0
2	HEC	A	105	43/43	0.99	0.08	0.13	8,10,12,13	0
2	HEC	B	105	43/43	0.99	0.08	-0.02	9,10,14,15	0
2	HEC	C	105	43/43	0.99	0.07	-0.35	10,12,16,23	0
3	PO4	A	1106	5/5	0.94	0.12	-	28,29,34,35	5

6.5 Other polymers (i)

There are no such residues in this entry.