



wwPDB EM Validation Summary Report ⓘ

Mar 15, 2026 – 12:20 AM JST

PDB ID : 9U32 / pdb_00009u32
EMDB ID : EMD-63808
Title : Plant chloroplast dicarboxylate transporter AtDiT2.1 bound with Glu
Authors : Yang, Z.; Zhang, P.
Deposited on : 2025-03-17
Resolution : 2.51 Å(reported)

This is a wwPDB EM 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/EMValidationReportHelp>

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:

EMDB validation analysis : **FAILED**
Mogul : 1.8.5 (274361), CSD as541be (2020)
MolProbity : 4-5-2 with Phenix2.0
buster-report : 1.1.7 (2018)
Percentile statistics : 20231227.v01 (using entries in the PDB archive December 27th 2023)
EM percentile statistics : **NOT EXECUTED**
MapQ : **FAILED**
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.48.1

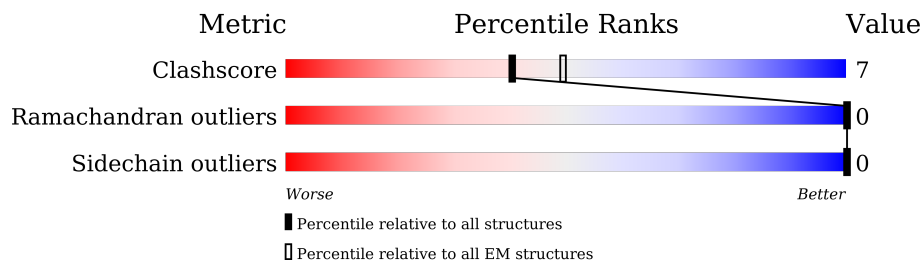
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

ELECTRON MICROSCOPY

The reported resolution of this entry is 2.51 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)	EM structures (#Entries)
Clashscore	210492	15764
Ramachandran outliers	207382	16835
Sidechain outliers	206894	16415

The table below summarises the geometric issues observed across the polymeric chains and their fit to the map. The red, orange, yellow and green segments of the 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 $\leq 5\%$

Mol	Chain	Length	Quality of chain
1	A	522	
1	B	522	

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	GLU	A	601	-	-	X	-
2	GLU	B	601	-	-	X	-

2 Entry composition i

There are 4 unique types of molecules in this entry. The entry contains 7306 atoms, of which 98 are hydrogens and 0 are deuteriums.

In the tables below, 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 Dicarboxylate transporter 2.1, chloroplastic.

Mol	Chain	Residues	Atoms					AltConf	Trace
			Total	C	N	O	S		
1	A	473	3557	2369	554	619	15	0	0
1	B	473	3557	2369	554	619	15	0	0

There are 54 discrepancies between the modelled and reference sequences:

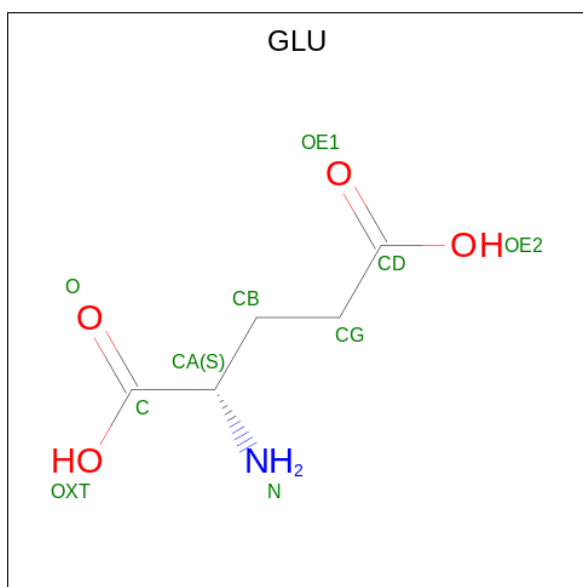
Chain	Residue	Modelled	Actual	Comment	Reference
A	42	MET	-	initiating methionine	UNP Q9FMF7
A	43	ASP	-	expression tag	UNP Q9FMF7
A	44	TYR	-	expression tag	UNP Q9FMF7
A	45	LYS	-	expression tag	UNP Q9FMF7
A	46	ASP	-	expression tag	UNP Q9FMF7
A	47	ASP	-	expression tag	UNP Q9FMF7
A	48	ASP	-	expression tag	UNP Q9FMF7
A	49	ASP	-	expression tag	UNP Q9FMF7
A	50	LYS	-	expression tag	UNP Q9FMF7
A	51	ASP	-	expression tag	UNP Q9FMF7
A	52	TYR	-	expression tag	UNP Q9FMF7
A	53	LYS	-	expression tag	UNP Q9FMF7
A	54	ASP	-	expression tag	UNP Q9FMF7
A	55	ASP	-	expression tag	UNP Q9FMF7
A	56	ASP	-	expression tag	UNP Q9FMF7
A	57	ASP	-	expression tag	UNP Q9FMF7
A	58	LYS	-	expression tag	UNP Q9FMF7
A	59	ASP	-	expression tag	UNP Q9FMF7
A	60	TYR	-	expression tag	UNP Q9FMF7
A	61	LYS	-	expression tag	UNP Q9FMF7
A	62	ASP	-	expression tag	UNP Q9FMF7
A	63	ASP	-	expression tag	UNP Q9FMF7
A	64	ASP	-	expression tag	UNP Q9FMF7
A	65	ASP	-	expression tag	UNP Q9FMF7
A	66	LYS	-	expression tag	UNP Q9FMF7
A	67	LEU	-	expression tag	UNP Q9FMF7

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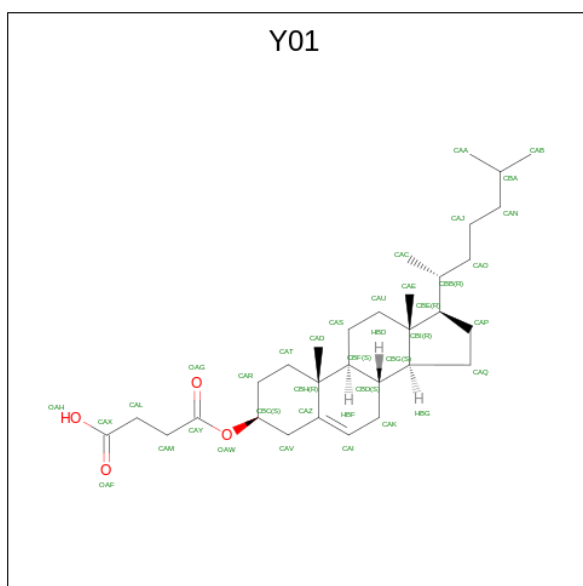
Chain	Residue	Modelled	Actual	Comment	Reference
A	68	GLU	-	expression tag	UNP Q9FMF7
B	42	MET	-	initiating methionine	UNP Q9FMF7
B	43	ASP	-	expression tag	UNP Q9FMF7
B	44	TYR	-	expression tag	UNP Q9FMF7
B	45	LYS	-	expression tag	UNP Q9FMF7
B	46	ASP	-	expression tag	UNP Q9FMF7
B	47	ASP	-	expression tag	UNP Q9FMF7
B	48	ASP	-	expression tag	UNP Q9FMF7
B	49	ASP	-	expression tag	UNP Q9FMF7
B	50	LYS	-	expression tag	UNP Q9FMF7
B	51	ASP	-	expression tag	UNP Q9FMF7
B	52	TYR	-	expression tag	UNP Q9FMF7
B	53	LYS	-	expression tag	UNP Q9FMF7
B	54	ASP	-	expression tag	UNP Q9FMF7
B	55	ASP	-	expression tag	UNP Q9FMF7
B	56	ASP	-	expression tag	UNP Q9FMF7
B	57	ASP	-	expression tag	UNP Q9FMF7
B	58	LYS	-	expression tag	UNP Q9FMF7
B	59	ASP	-	expression tag	UNP Q9FMF7
B	60	TYR	-	expression tag	UNP Q9FMF7
B	61	LYS	-	expression tag	UNP Q9FMF7
B	62	ASP	-	expression tag	UNP Q9FMF7
B	63	ASP	-	expression tag	UNP Q9FMF7
B	64	ASP	-	expression tag	UNP Q9FMF7
B	65	ASP	-	expression tag	UNP Q9FMF7
B	66	LYS	-	expression tag	UNP Q9FMF7
B	67	LEU	-	expression tag	UNP Q9FMF7
B	68	GLU	-	expression tag	UNP Q9FMF7

- Molecule 2 is GLUTAMIC ACID (CCD ID: GLU) (formula: $C_5H_9NO_4$) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms				AltConf
			Total	C	N	O	
2	A	1	10	5	1	4	0
2	B	1	10	5	1	4	0

- Molecule 3 is CHOLESTEROL HEMISUCCINATE (CCD ID: Y01) (formula: $C_{31}H_{50}O_4$) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms				AltConf
			Total	C	H	O	
3	A	1	84	31	49	4	0

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Mol	Chain	Residues	Atoms				AltConf
			Total	C	H	O	
3	B	1	84	31	49	4	0

- Molecule 4 is water.

Mol	Chain	Residues	Atoms		AltConf
4	A	2	Total 2	O 2	0
4	B	2	Total 2	O 2	0

4 Experimental information

Property	Value	Source
EM reconstruction method	SINGLE PARTICLE	Depositor
Imposed symmetry	POINT, Not provided	
Number of particles used	507410	Depositor
Resolution determination method	FSC 0.143 CUT-OFF	Depositor
CTF correction method	PHASE FLIPPING AND AMPLITUDE CORRECTION	Depositor
Microscope	TFS KRIOS	Depositor
Voltage (kV)	300	Depositor
Electron dose ($e^-/\text{\AA}^2$)	50	Depositor
Minimum defocus (nm)	1200	Depositor
Maximum defocus (nm)	2200	Depositor
Magnification	Not provided	
Image detector	TFS FALCON 4i (4k x 4k)	Depositor

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: Y01

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	0.33	1/3655 (0.0%)	0.53	3/4997 (0.1%)
1	B	0.33	1/3655 (0.0%)	0.53	3/4997 (0.1%)
All	All	0.33	2/7310 (0.0%)	0.53	6/9994 (0.1%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	536	LYS	C-O	-8.85	1.14	1.24
1	B	536	LYS	C-O	-8.85	1.14	1.24

The worst 5 of 6 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	303	ASN	CB-CA-C	11.02	119.03	111.20
1	B	303	ASN	CB-CA-C	11.02	119.02	111.20
1	A	302	SER	CA-C-N	5.35	130.69	124.21
1	A	302	SER	C-N-CA	5.35	130.69	124.21
1	B	302	SER	CA-C-N	5.33	130.66	124.21

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	3557	0	3675	53	0
1	B	3557	0	3675	48	0
2	A	10	0	5	9	0
2	B	10	0	5	9	0
3	A	35	49	49	19	0
3	B	35	49	49	19	0
4	A	2	0	0	0	0
4	B	2	0	0	0	0
All	All	7208	98	7458	99	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 7.

The worst 5 of 99 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:B:418:PHE:CZ	1:B:474:THR:HG21	1.65	1.31
1:A:418:PHE:CZ	1:A:474:THR:HG21	1.65	1.27
1:B:508:LEU:HD13	3:B:602:Y01:HAN1	1.38	1.02
1:A:508:LEU:HD13	3:A:602:Y01:HAN1	1.38	1.01
1:B:453:PRO:HB3	3:B:602:Y01:HAM1	1.44	0.98

There are no symmetry-related clashes.

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 PDB entries followed by that with respect to all EM entries.

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	471/522 (90%)	458 (97%)	13 (3%)	0	100	100
1	B	471/522 (90%)	458 (97%)	13 (3%)	0	100	100
All	All	942/1044 (90%)	916 (97%)	26 (3%)	0	100	100

There are no Ramachandran outliers to report.

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 PDB entries followed by that with respect to all EM entries.

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	374/419 (89%)	374 (100%)	0	100	100
1	B	374/419 (89%)	374 (100%)	0	100	100
All	All	748/838 (89%)	748 (100%)	0	100	100

There are no protein residues with a non-rotameric sidechain to report.

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 6 such sidechains are listed below:

Mol	Chain	Res	Type
1	B	92	GLN
1	B	358	ASN
1	B	473	GLN
1	A	358	ASN
1	A	92	GLN

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](#)

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
3	Y01	A	602	-	38,38,38	0.54	0	57,57,57	0.77	2 (3%)
2	GLU	B	601	-	8,9,9	1.63	1 (12%)	10,11,11	2.38	3 (30%)
2	GLU	A	601	-	8,9,9	1.63	1 (12%)	10,11,11	2.37	3 (30%)
3	Y01	B	602	-	38,38,38	0.54	0	57,57,57	0.77	2 (3%)

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
3	Y01	A	602	-	-	13/19/77/77	0/4/4/4
2	GLU	B	601	-	-	3/9/9/9	-
2	GLU	A	601	-	-	3/9/9/9	-
3	Y01	B	602	-	-	13/19/77/77	0/4/4/4

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	601	GLU	OXT-C	-3.38	1.19	1.30
2	B	601	GLU	OXT-C	-3.38	1.19	1.30

The worst 5 of 10 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	601	GLU	CB-CA-C	5.75	123.98	110.30
2	A	601	GLU	CB-CA-C	5.73	123.94	110.30
3	B	602	Y01	CAP-CBE-CBB	2.36	115.79	112.15
3	A	602	Y01	CAP-CBE-CBB	2.33	115.75	112.15
2	B	601	GLU	OXT-C-O	-2.31	118.84	124.09

There are no chirality outliers.

5 of 32 torsion outliers are listed below:

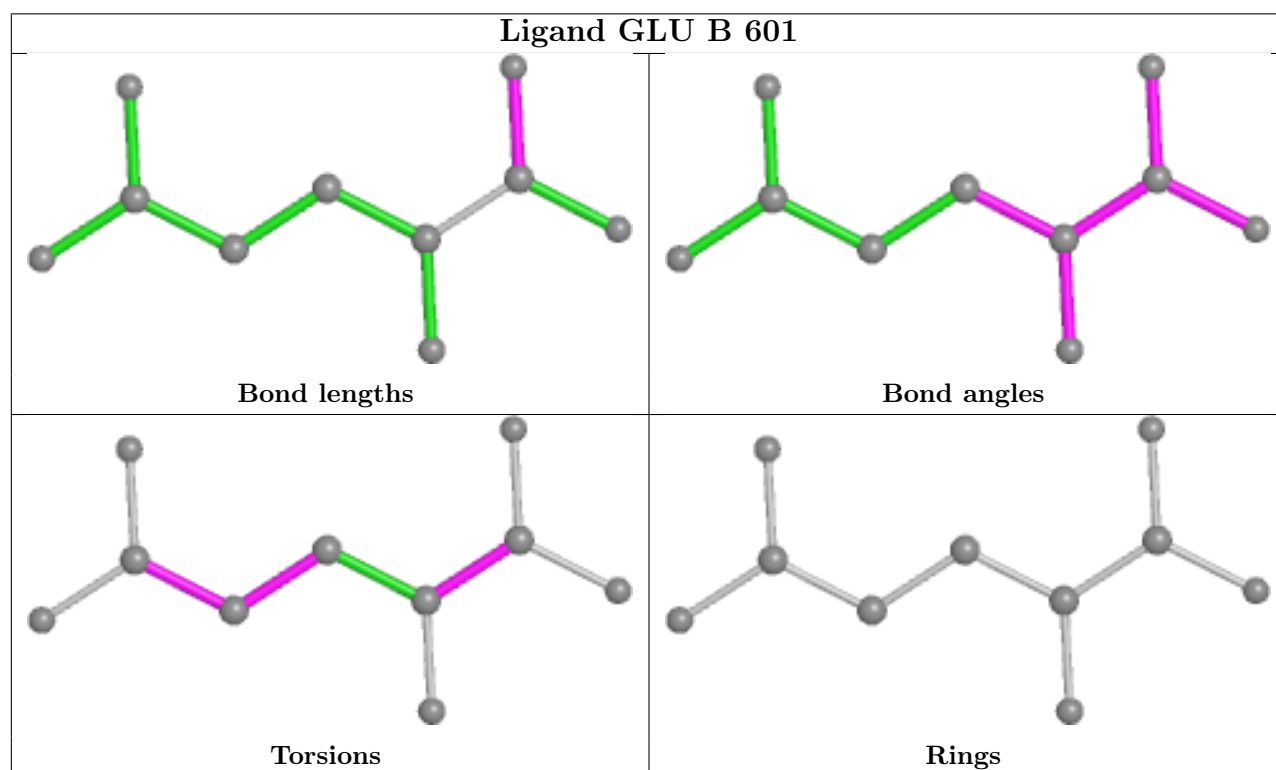
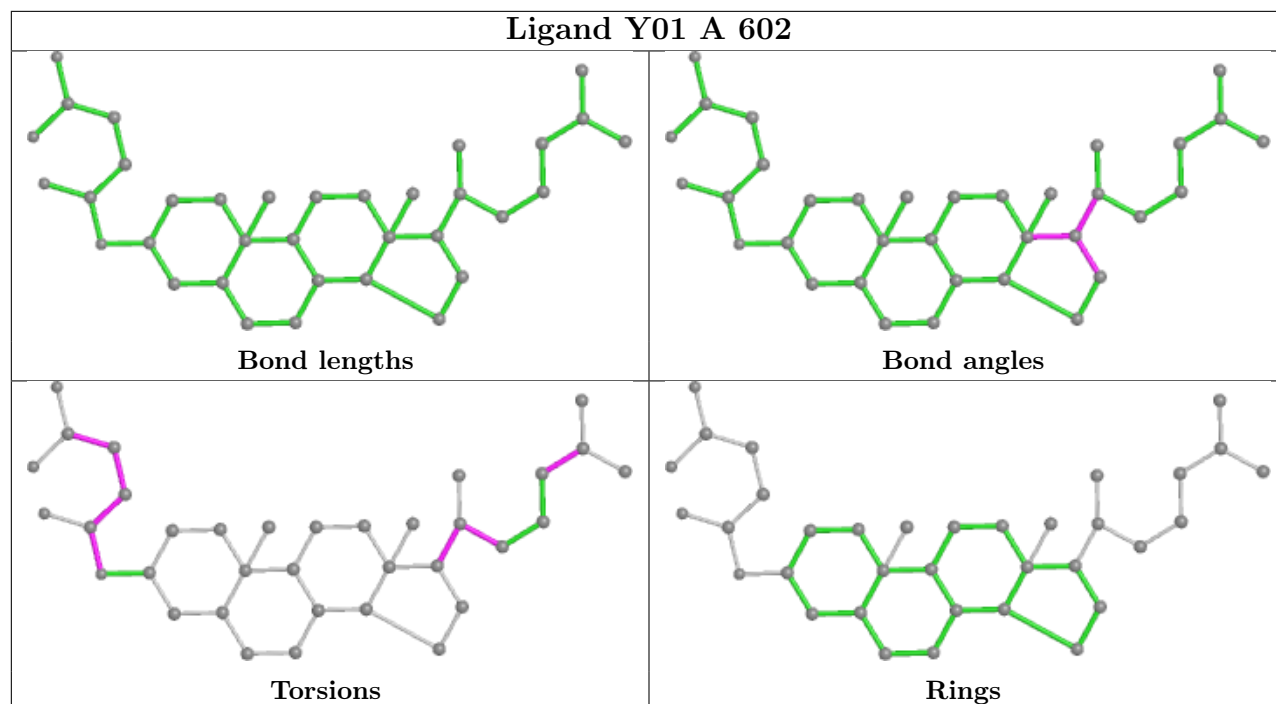
Mol	Chain	Res	Type	Atoms
3	A	602	Y01	CAO-CBB-CBE-CAP
3	A	602	Y01	CAC-CBB-CBE-CBI
3	B	602	Y01	CAO-CBB-CBE-CAP
3	B	602	Y01	CAC-CBB-CBE-CBI
3	A	602	Y01	CAC-CBB-CBE-CAP

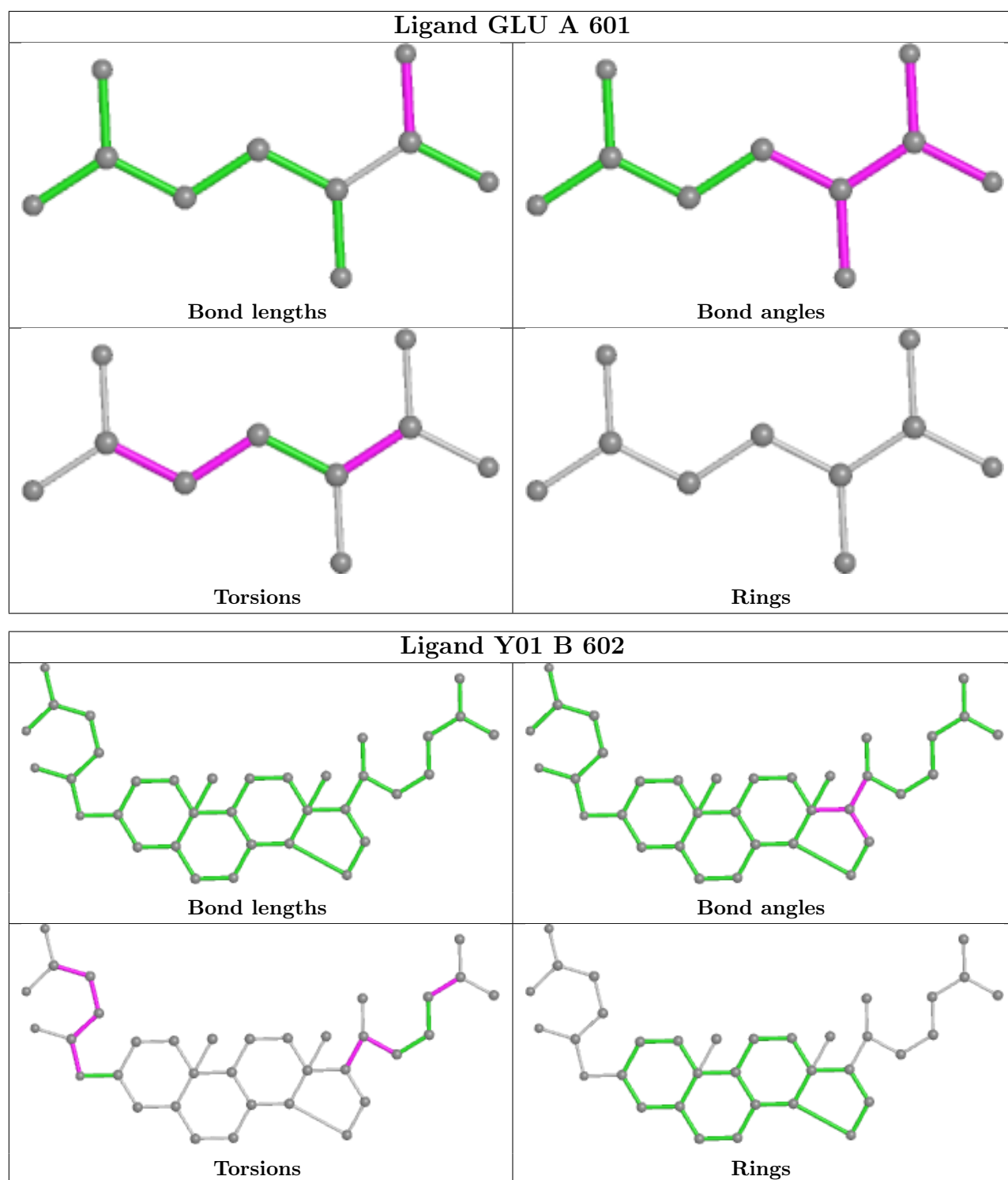
There are no ring outliers.

4 monomers are involved in 56 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	602	Y01	19	0
2	B	601	GLU	9	0
2	A	601	GLU	9	0
3	B	602	Y01	19	0

The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less than 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient equivalents in the CSD to analyse the geometry.





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.