Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Four intricately caged polycyclic polyprenylated acylphloroglucinols from *Garcinia multiflora* fruits

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Electronic Supplementary Information

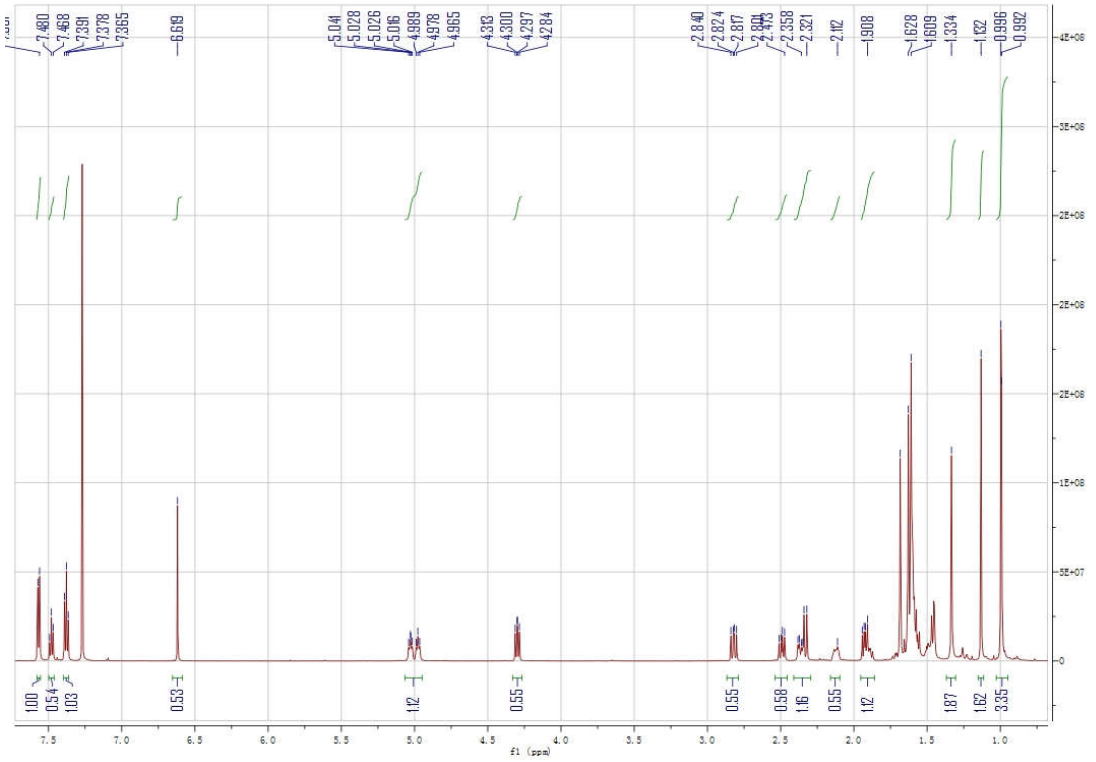


Fig 1. The ^{1}H-NMR spectrum of 1

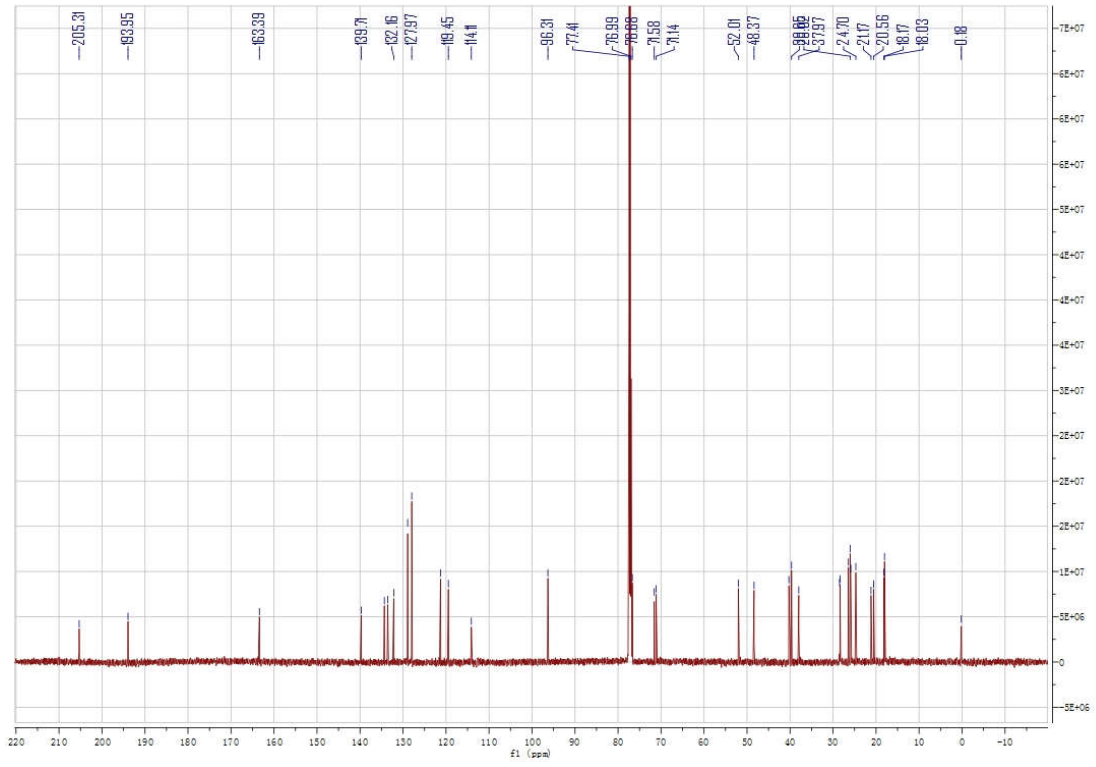


Fig 2. The ^{13}C-NMR spectrum of 1

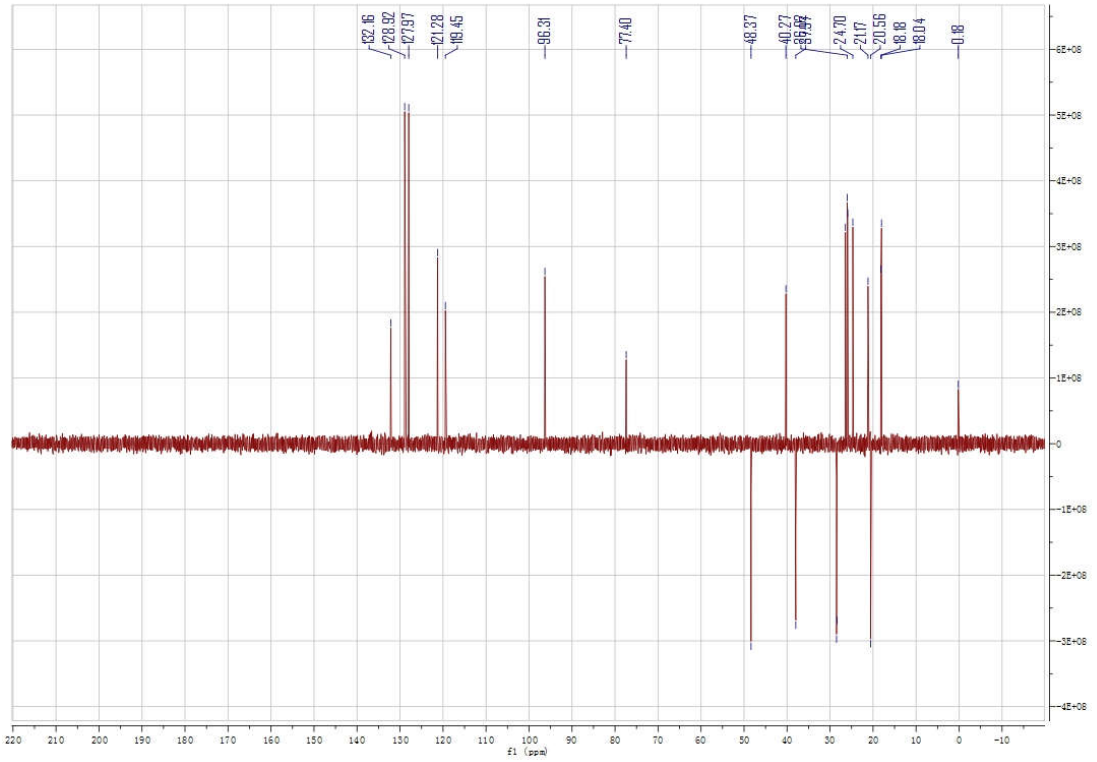


Fig 3. ^{13}C-NMR-DEPT spectrum of 1

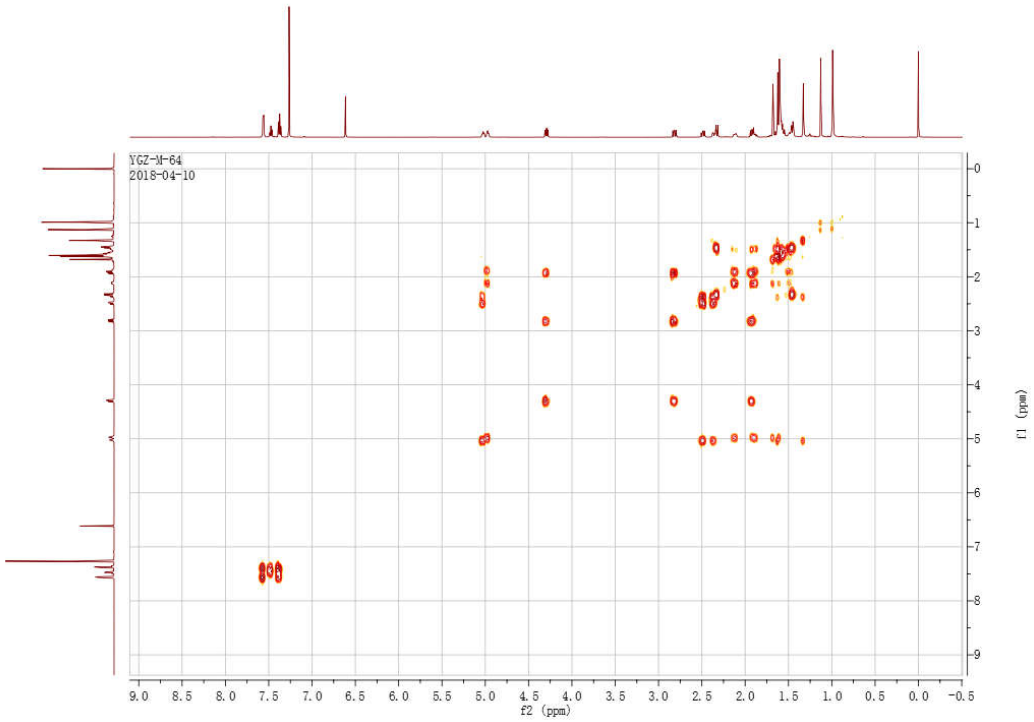


Fig 4. ^{1}H-^{1}H COSY spectrum of 1

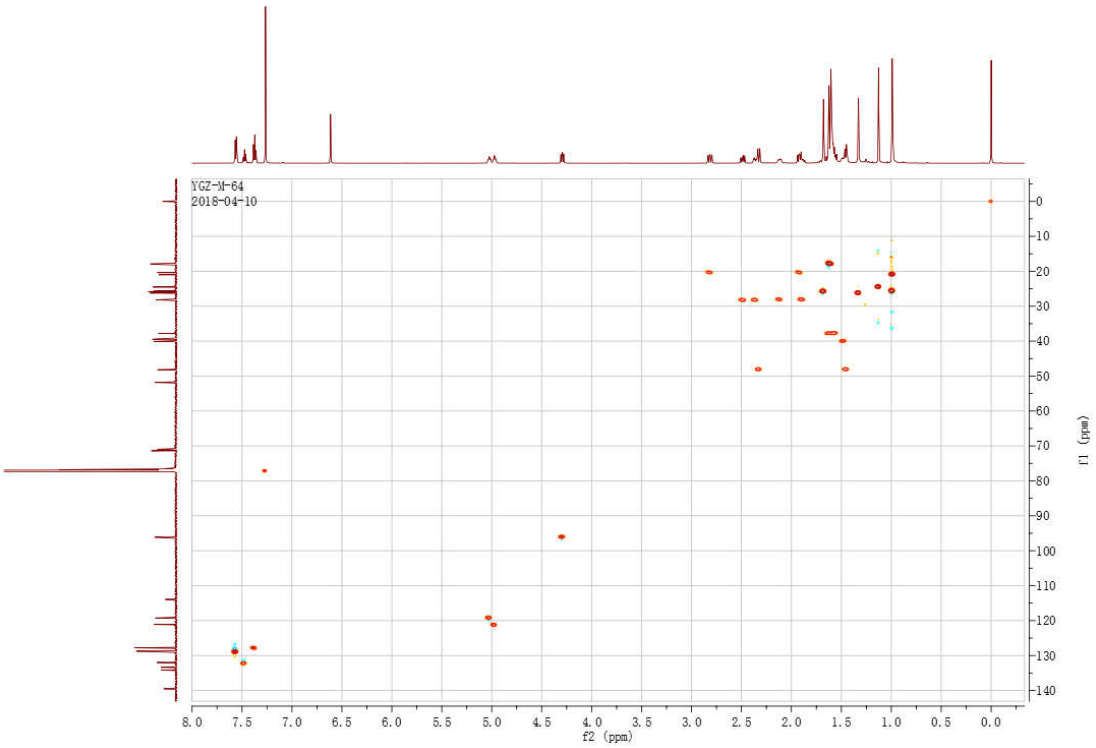
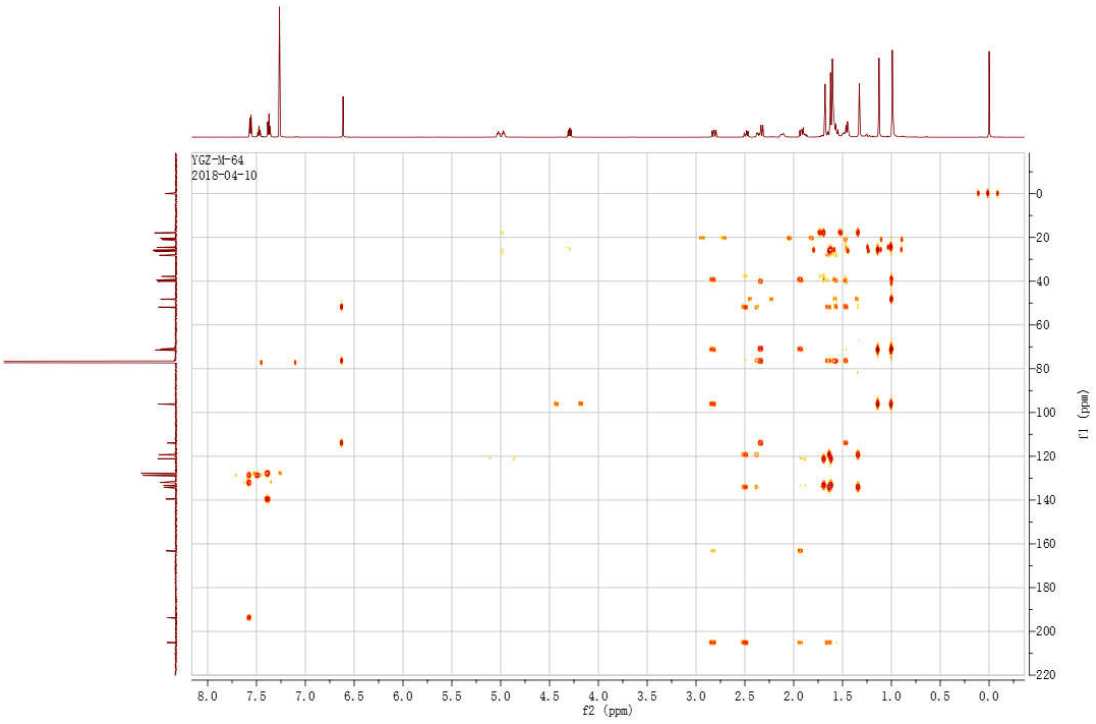


Fig 5. HSQC spectrum of 1



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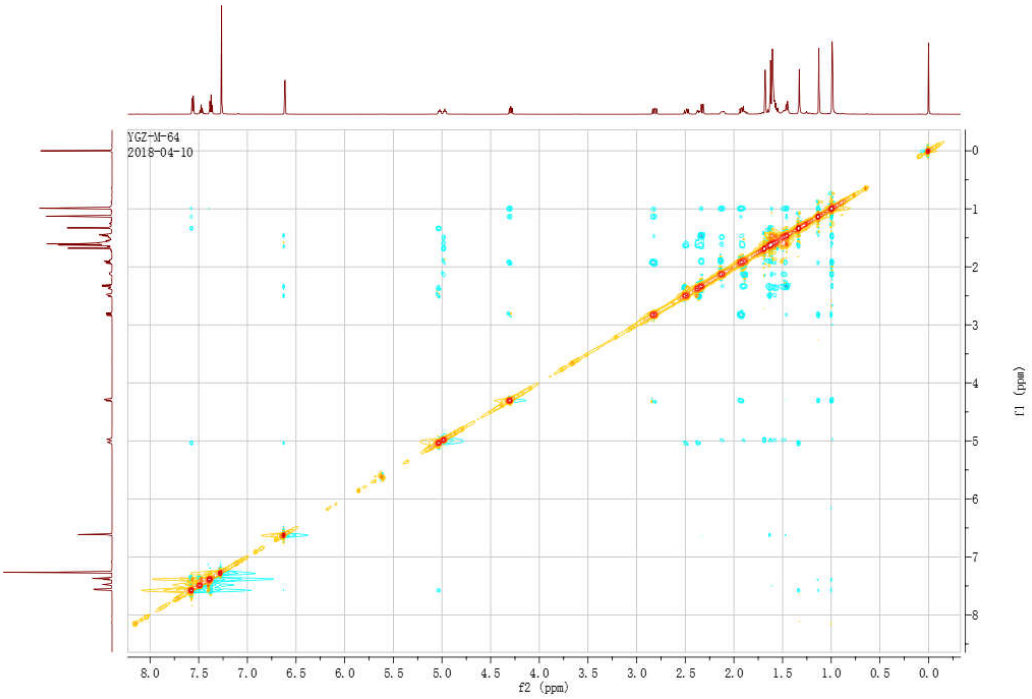

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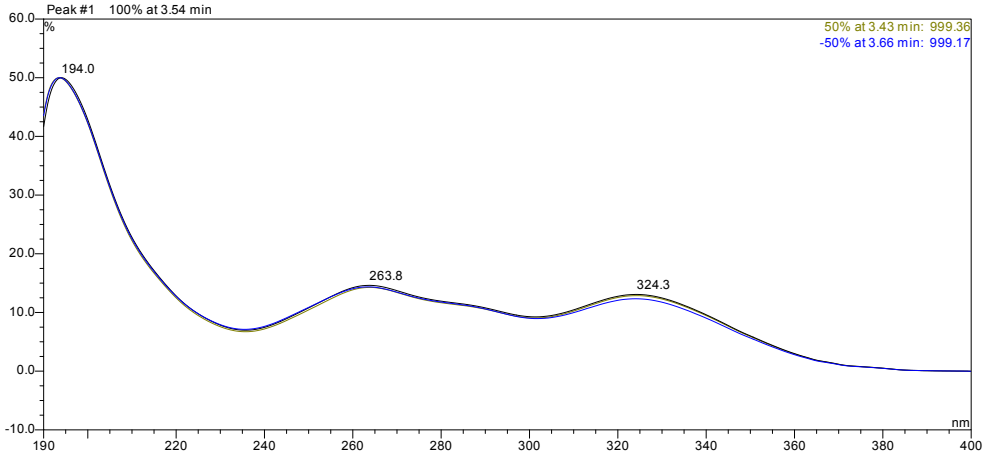


Fig 8. UV spectrum of 1

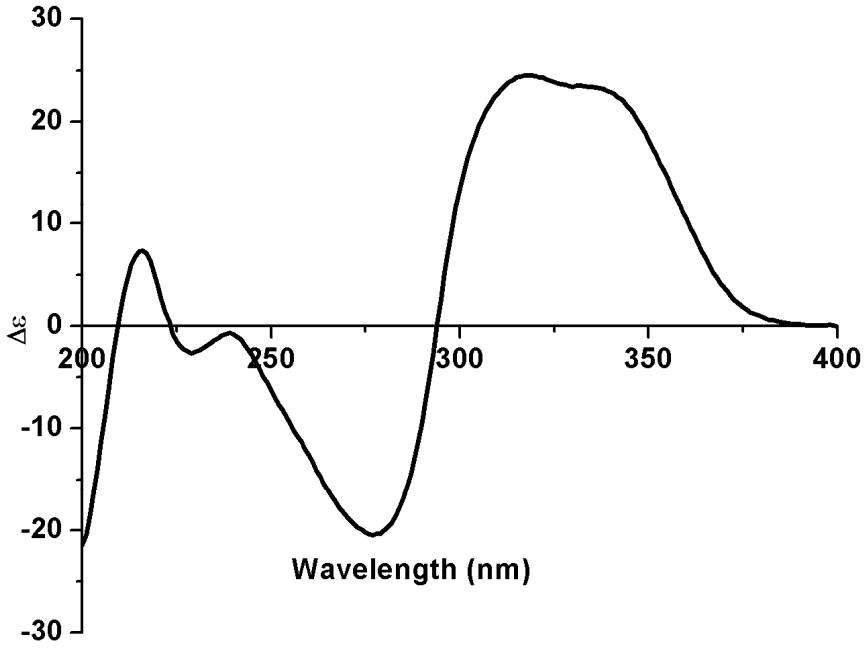


Fig 9. CD spectrum of 1

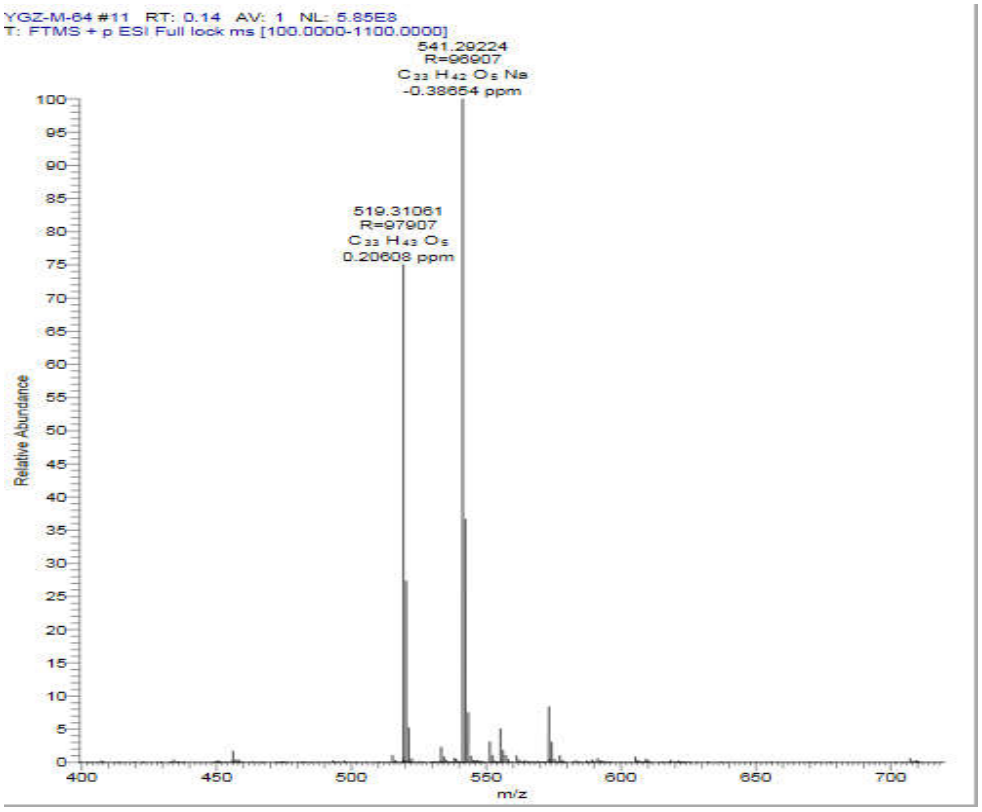


Fig 10. HR-ESI-MS of 1

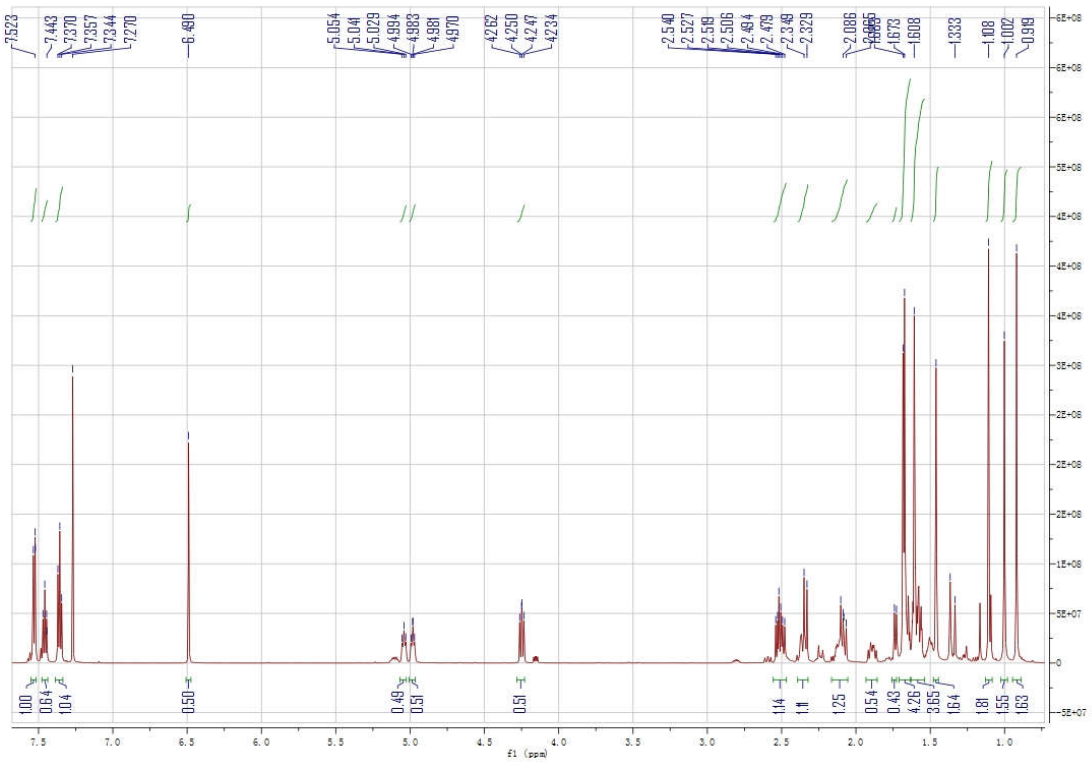
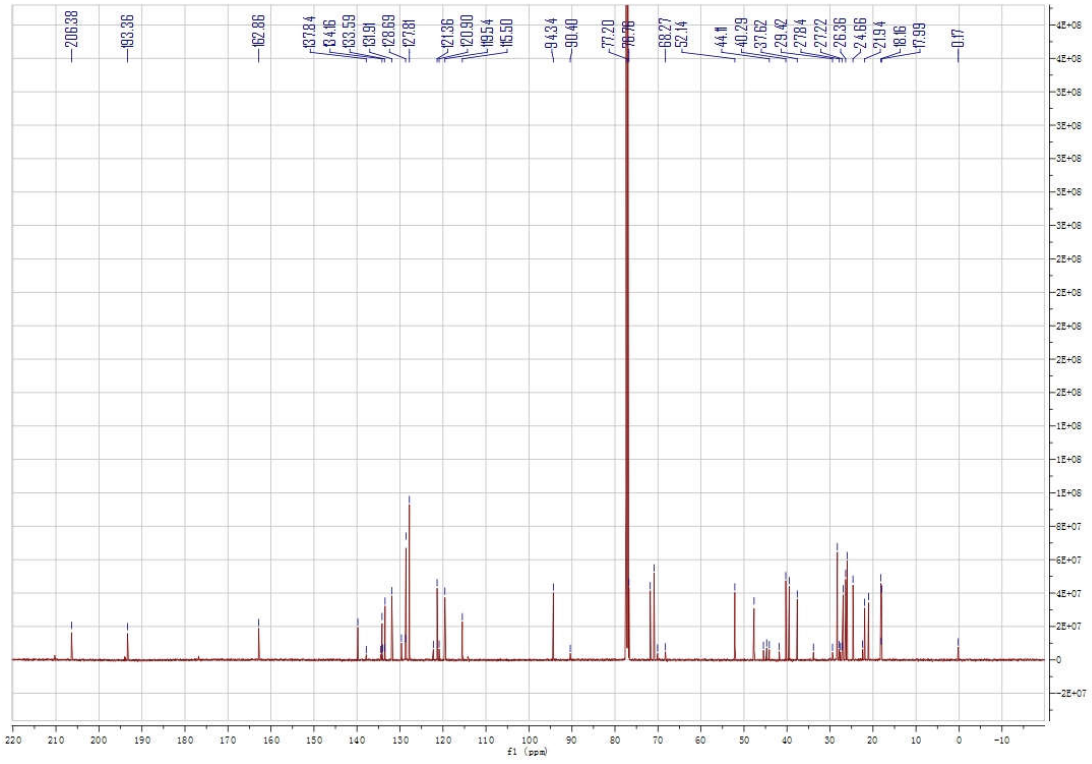


Fig 11. The ^{1}H-NMR spectrum of 2



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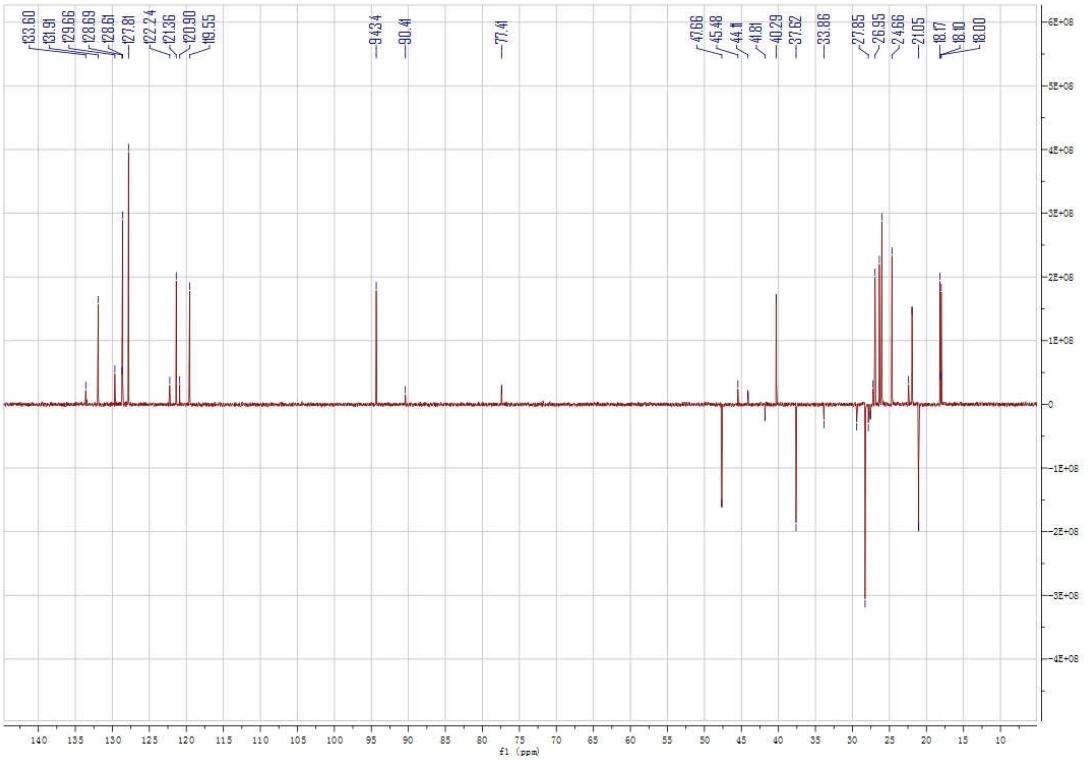


Fig 13. ^{13}C-NMR-DEPT spectrum of 2

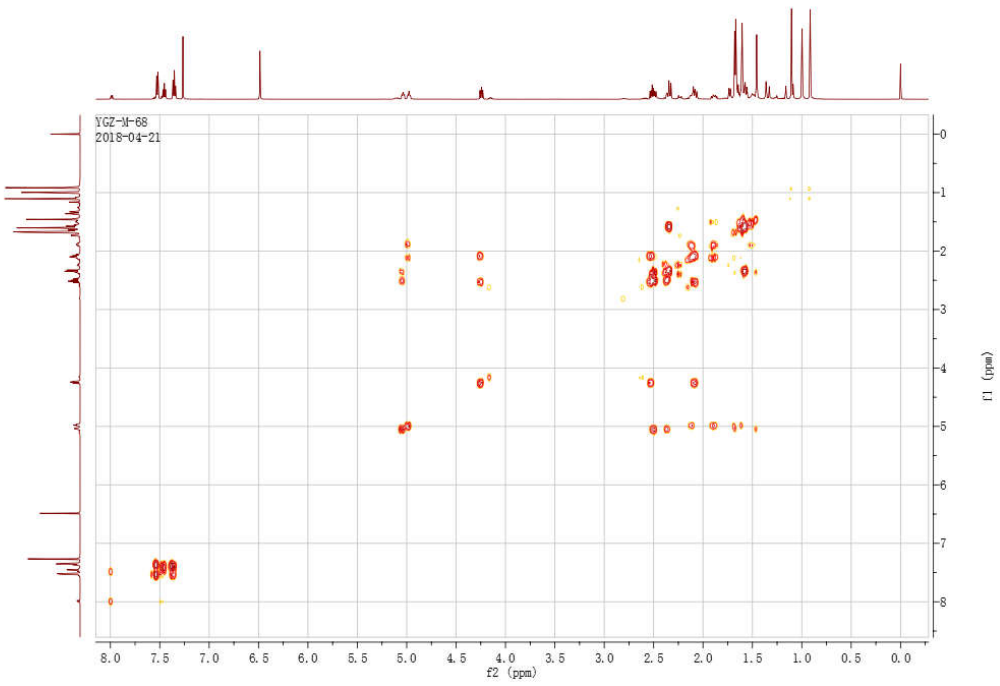


Fig 14. ^{1}H-^{1}H COSY spectrum of 2

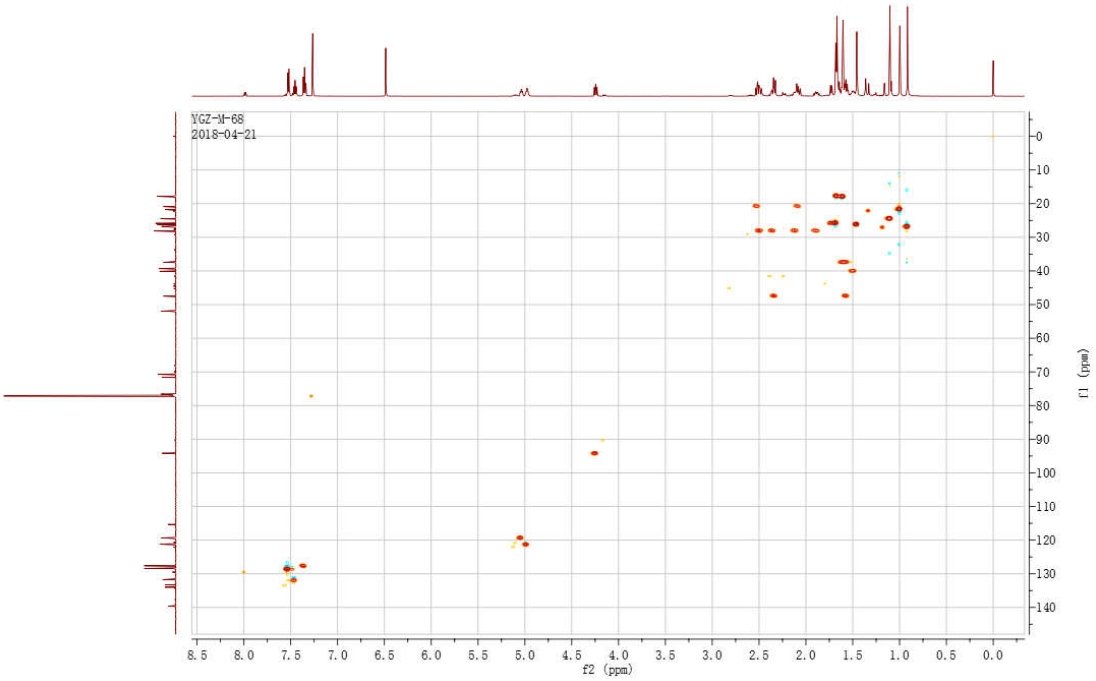
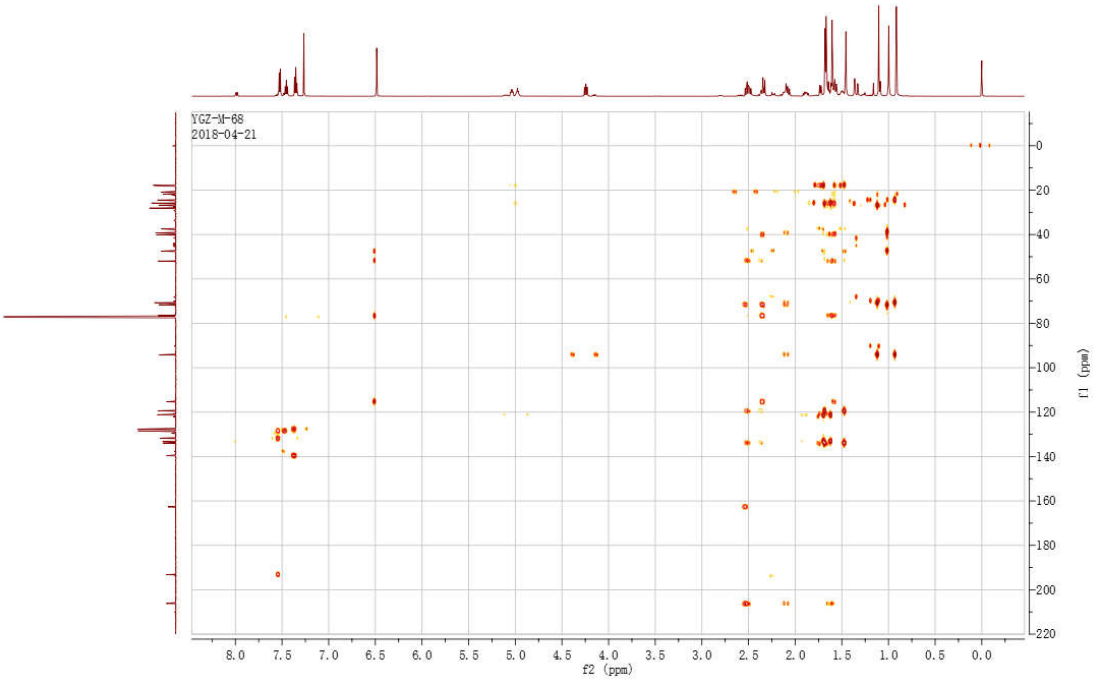


Fig 15. HSQC spectrum of 2



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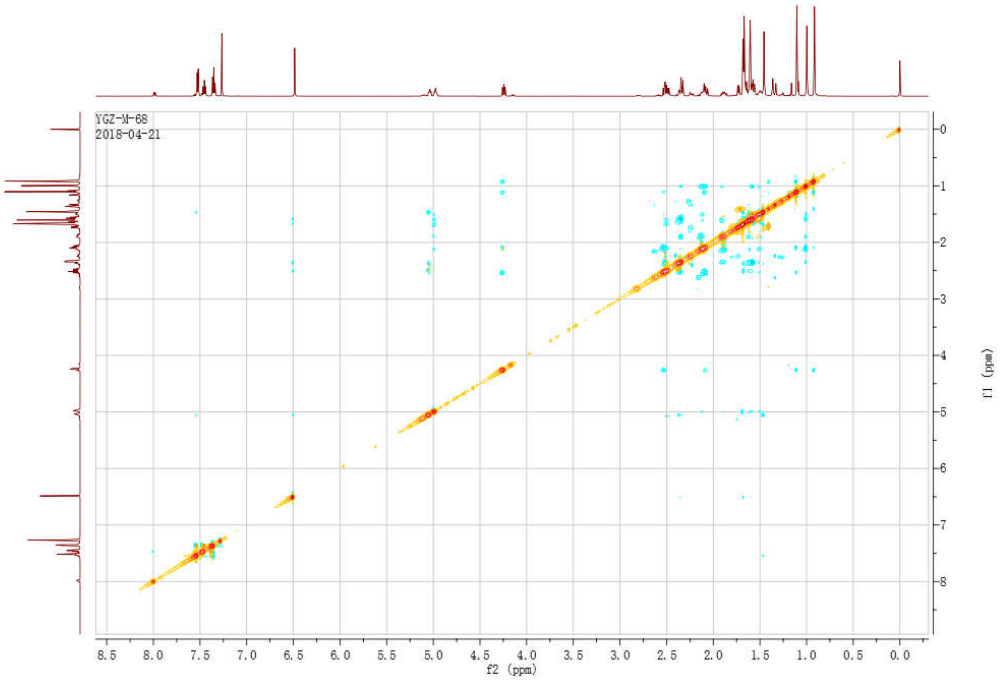

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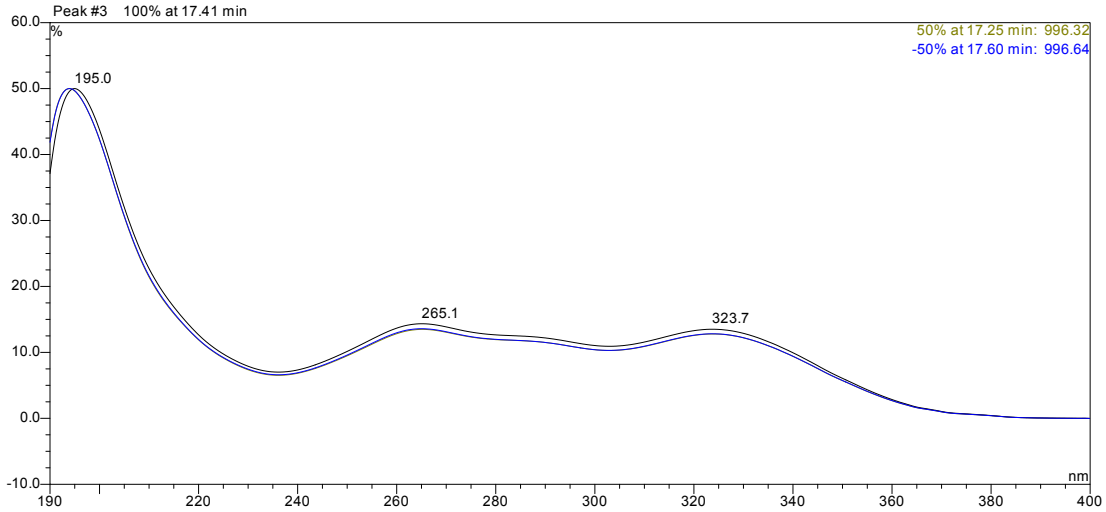


Fig 18. UV spectrum of 2

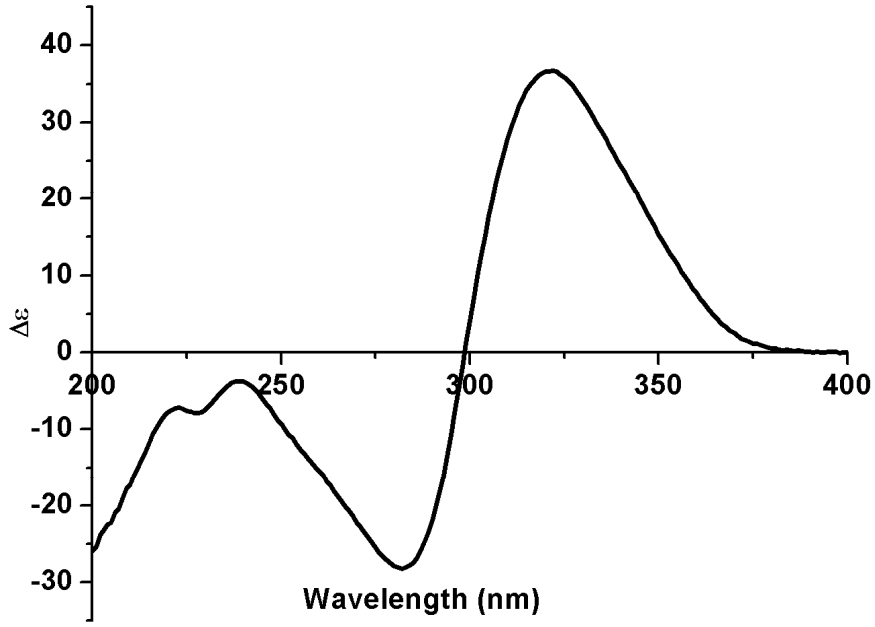


Fig 19. CD spectrum of 2

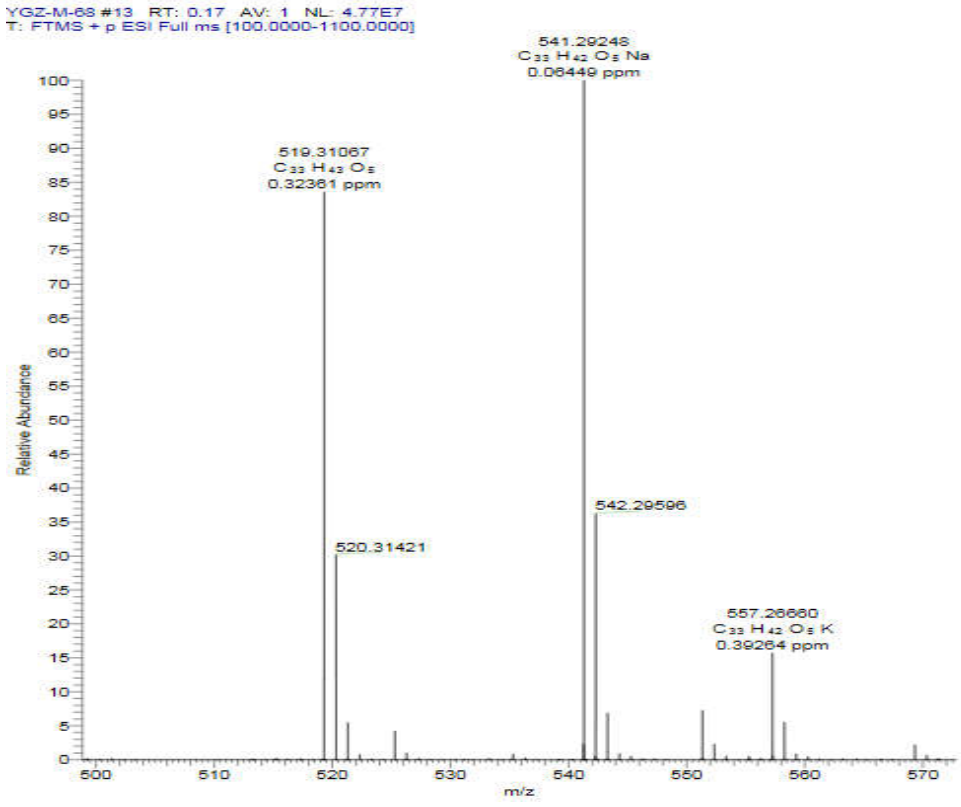


Fig 20. HR-ESI-MS of 2

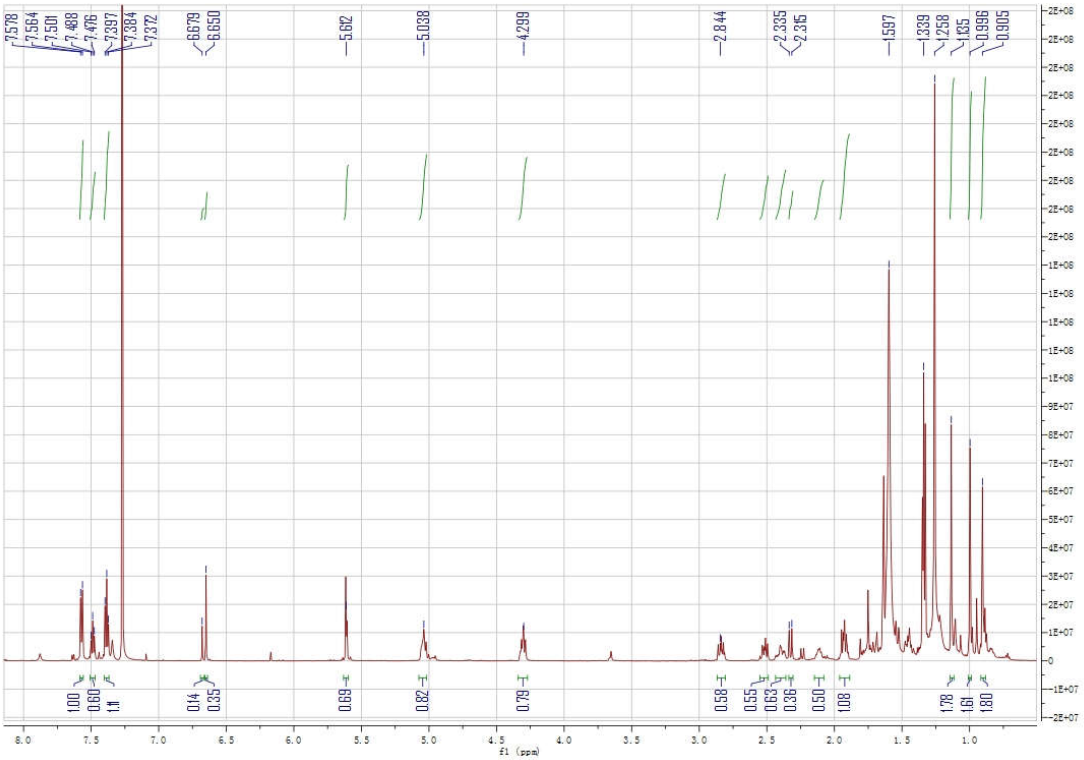


Fig 21. The ^{1}H-NMR spectrum of 3

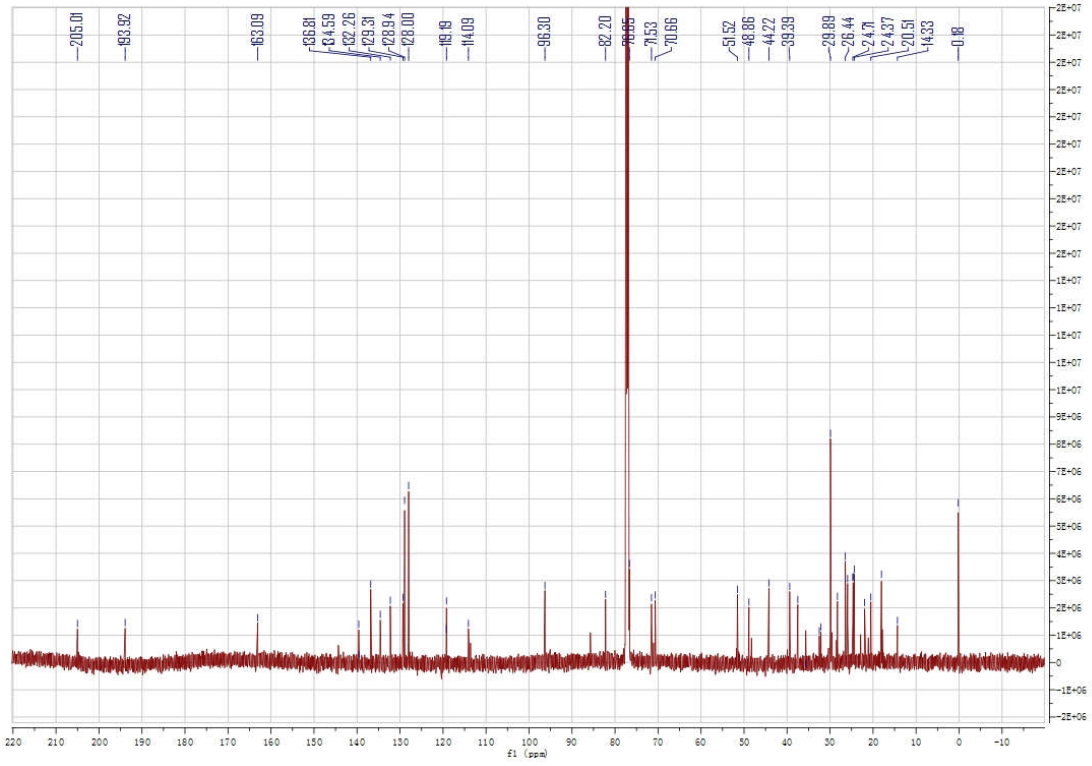


Fig 22. The ^{13}C-NMR spectrum of 3

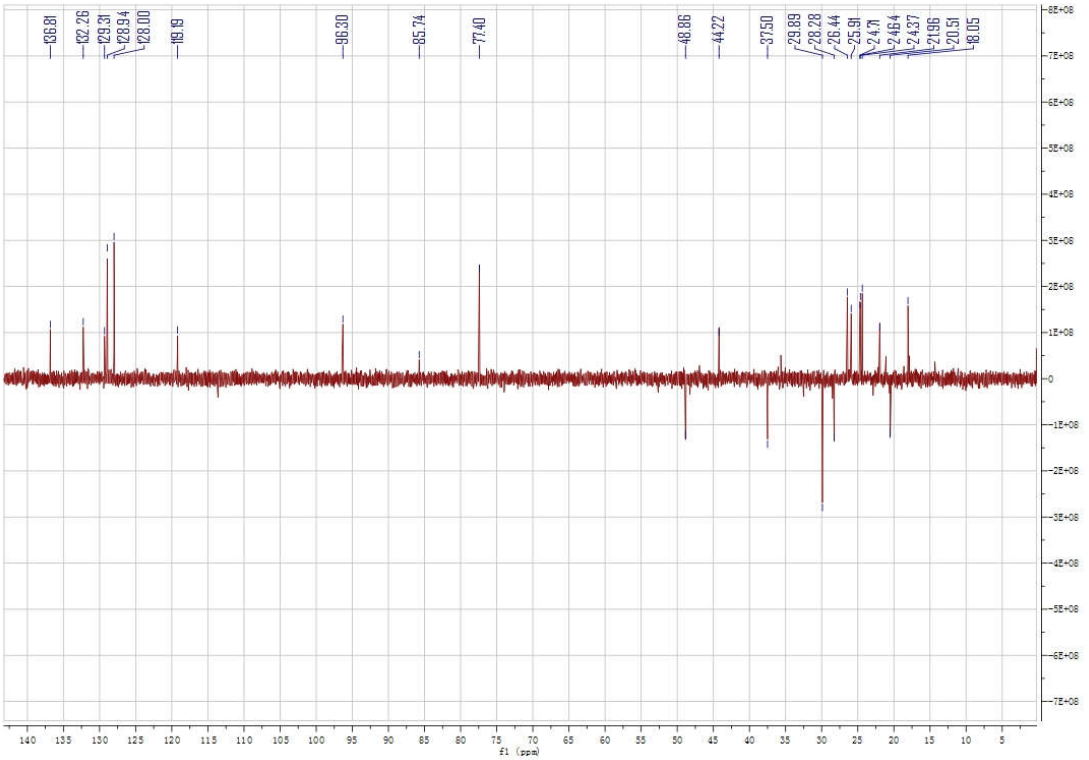


Fig 23. ^{13}C-NMR-DEPT spectrum of 3

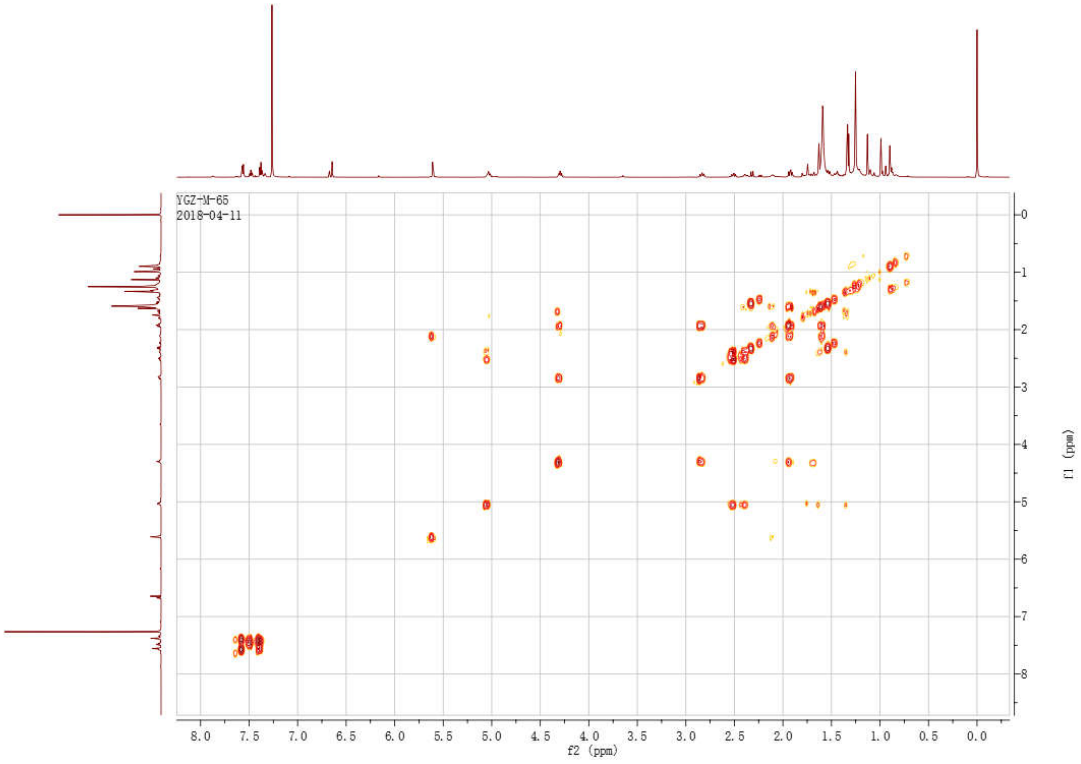


Fig 24. ^{1}H-^{1}H COSY spectrum of 3

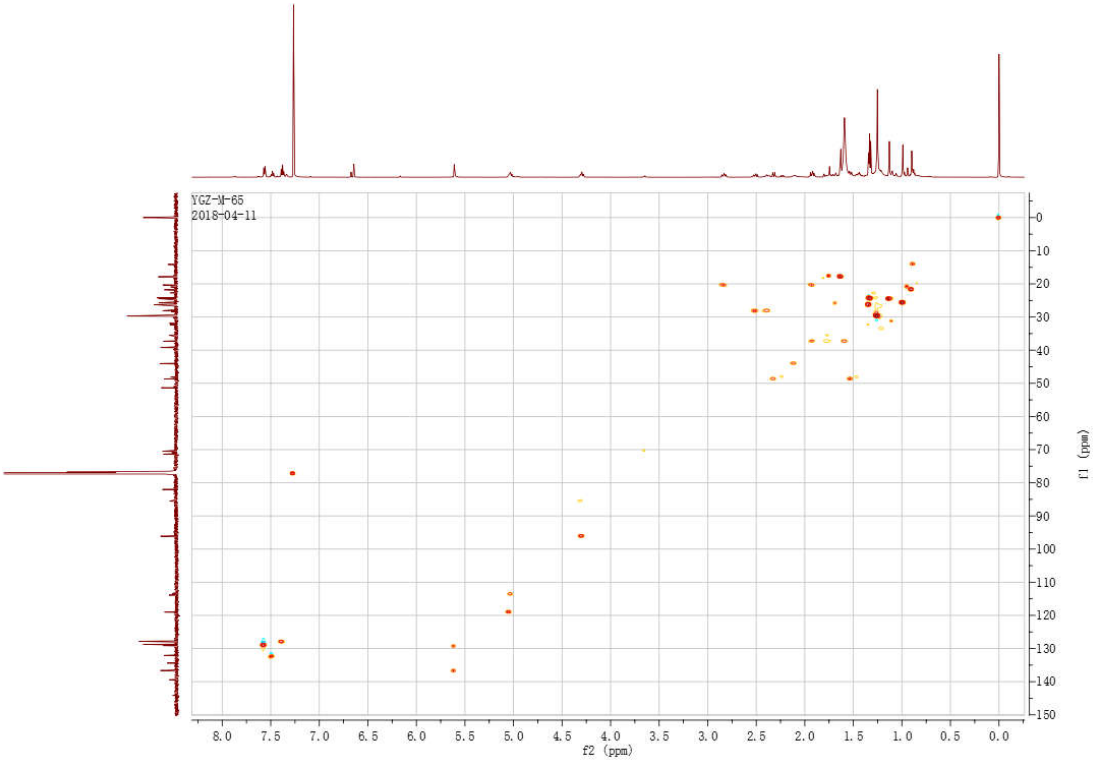
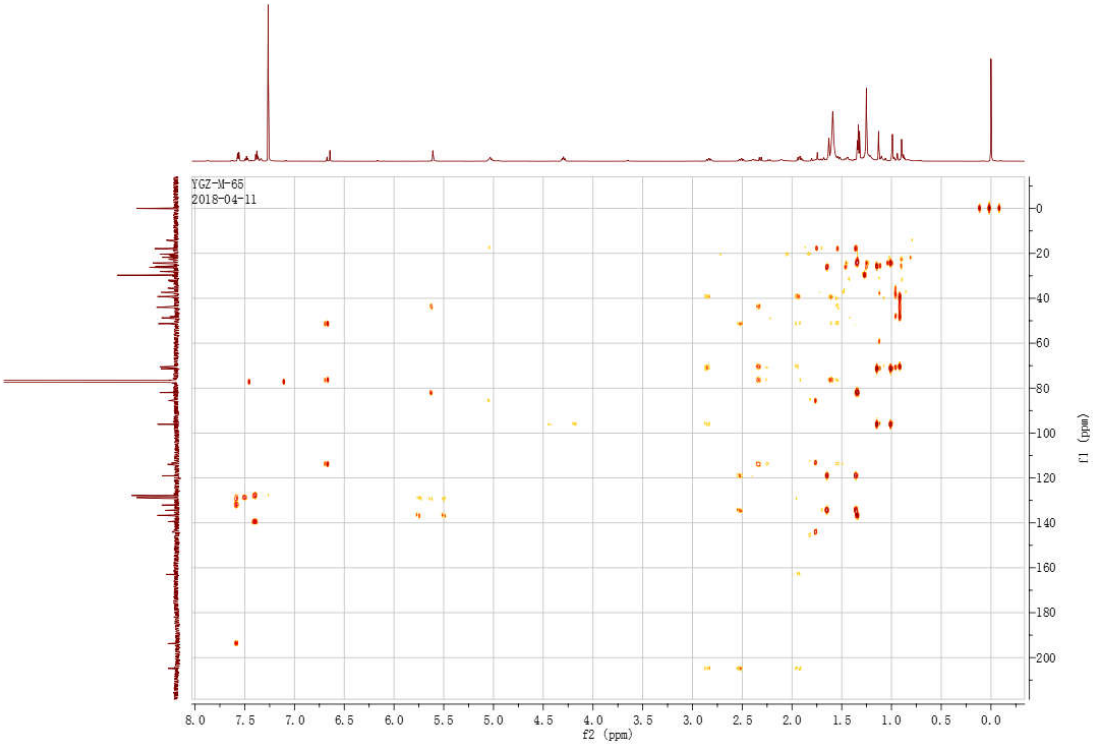


Fig 25. HSQC spectrum of 3



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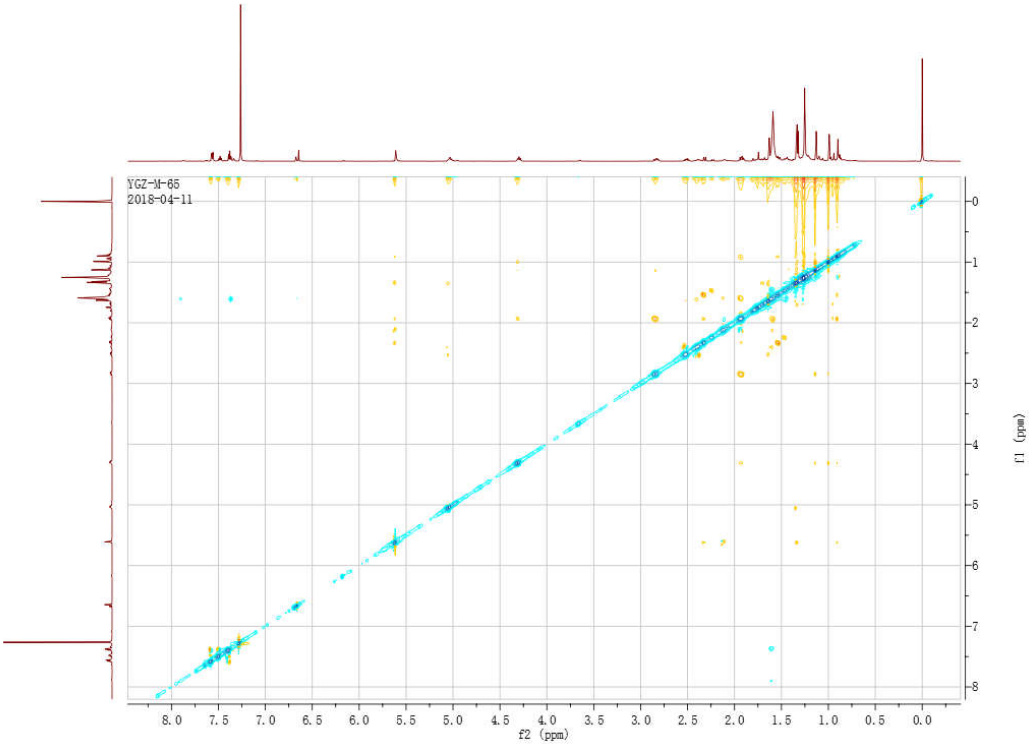

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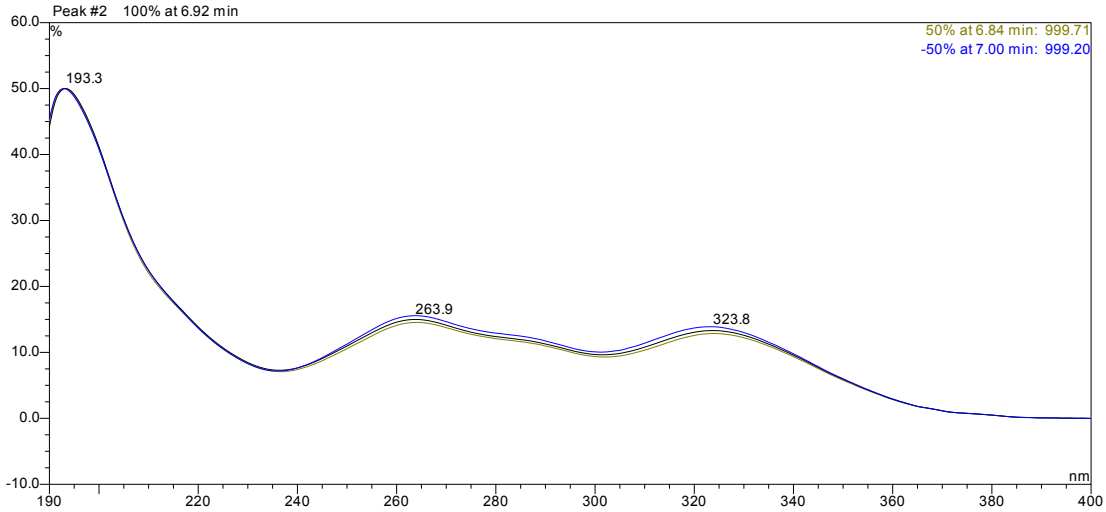
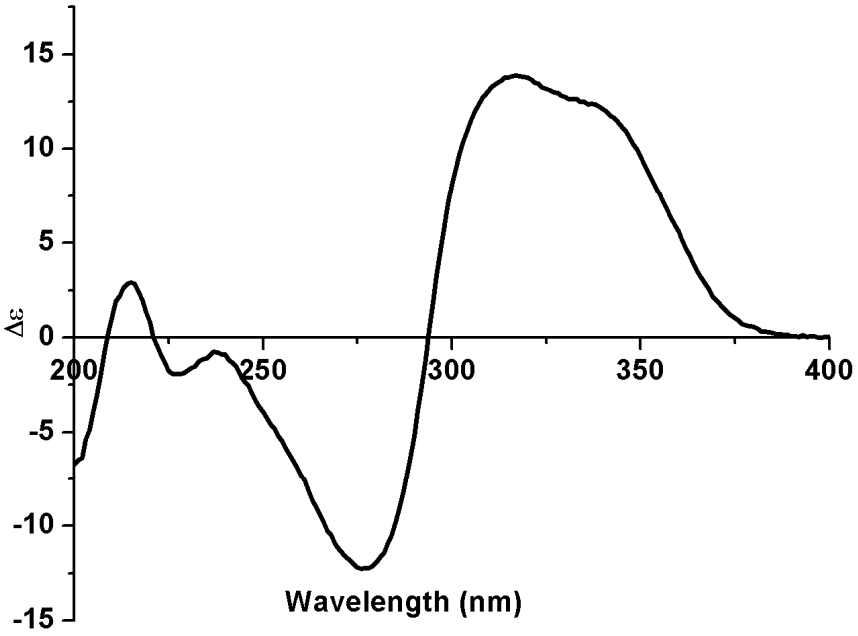


Fig 28. UV spectrum of 3



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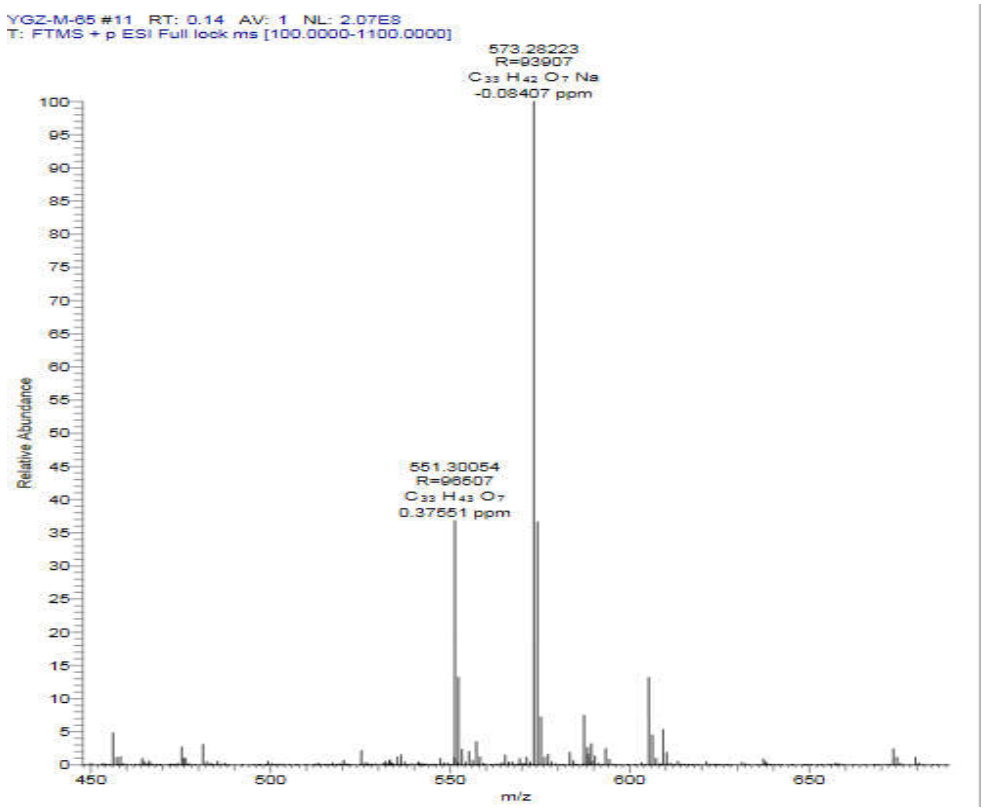

Fig 30. HR-ESI-MS of 3

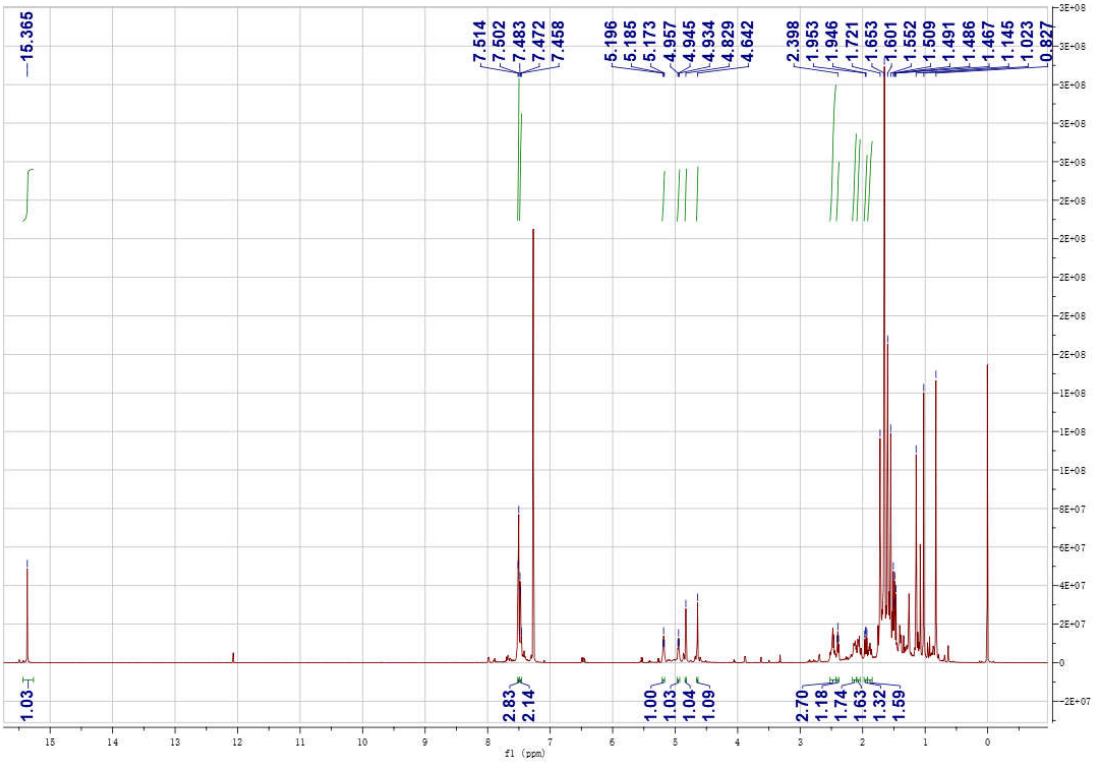

Fig 31. The ^{1}H-NMR spectrum of 4

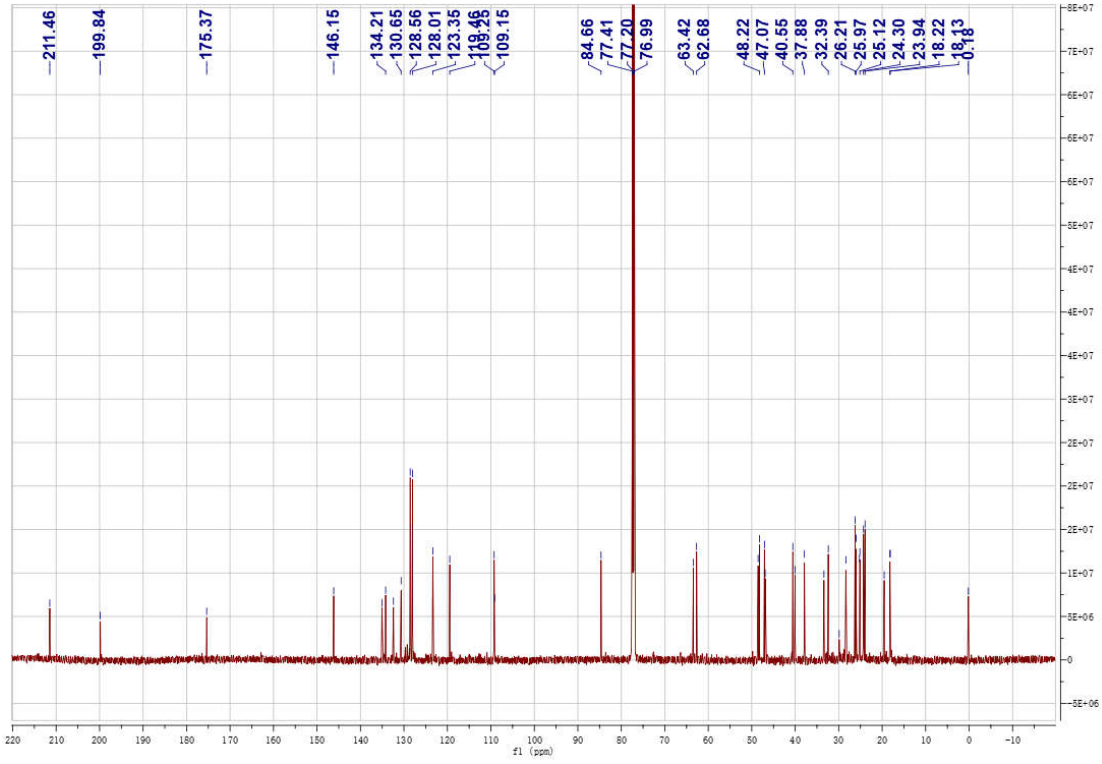

Fig 32. The ^{13}C-NMR spectrum of 4

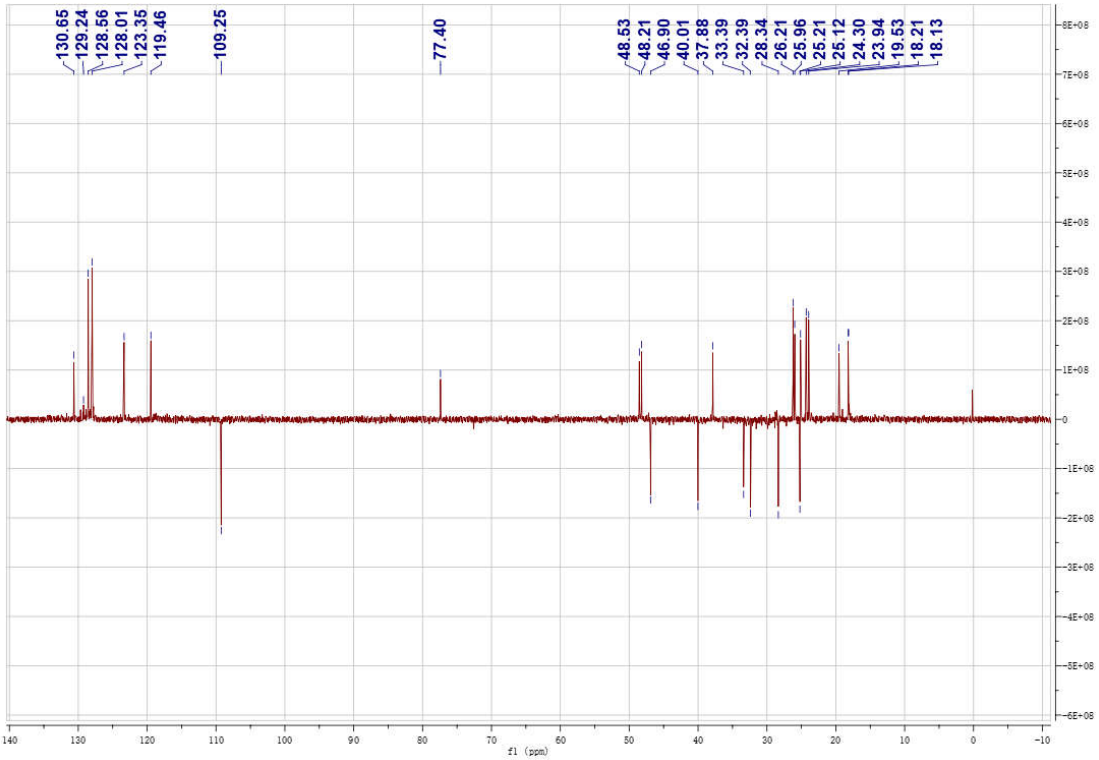

Fig 33. ^{13}C-NMR-DEPT spectrum of 4

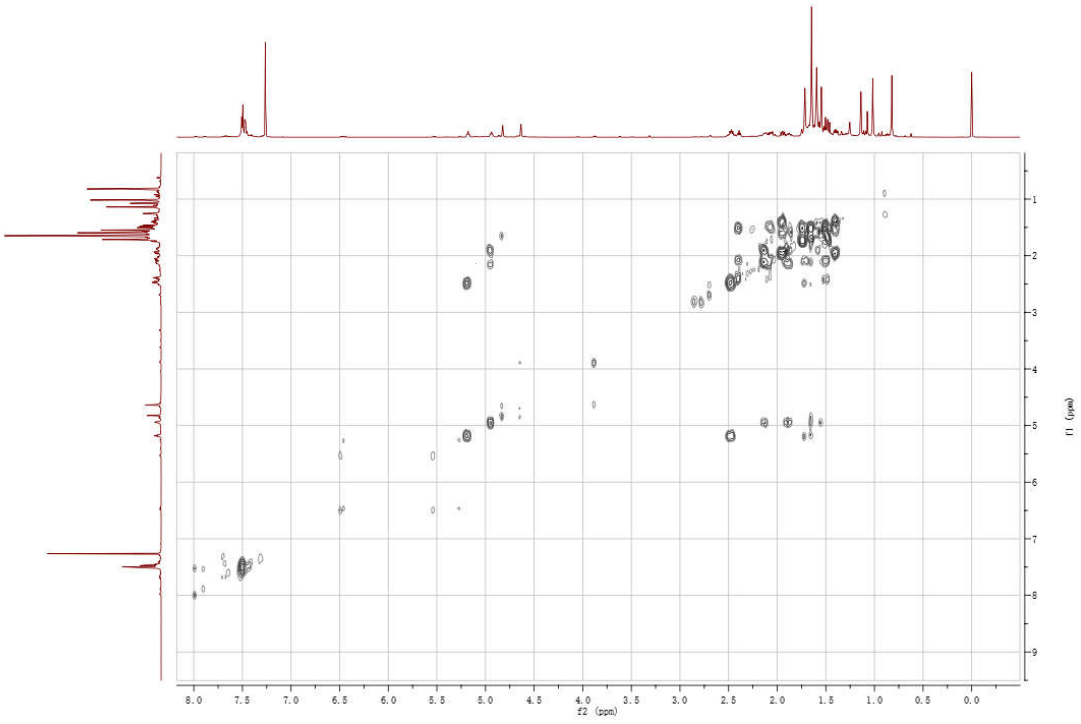

Fig 34. ^{1}H-^{1}H COSY spectrum of 4

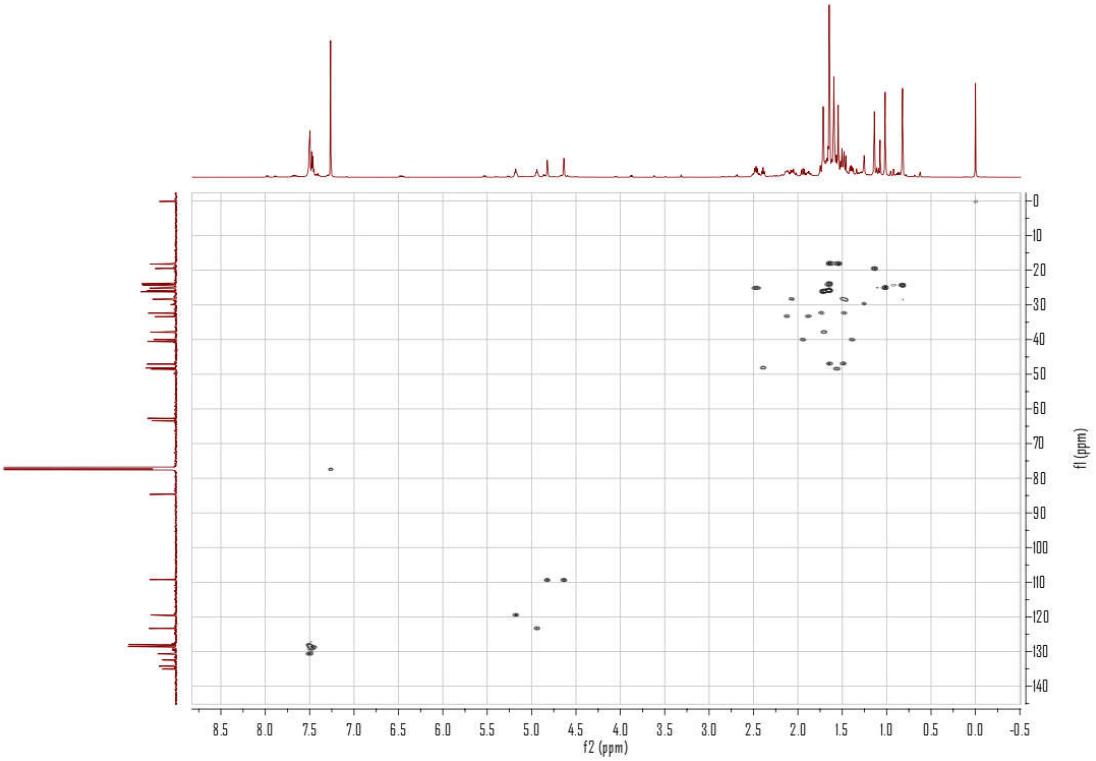

Fig 35. HSQC spectrum of 4

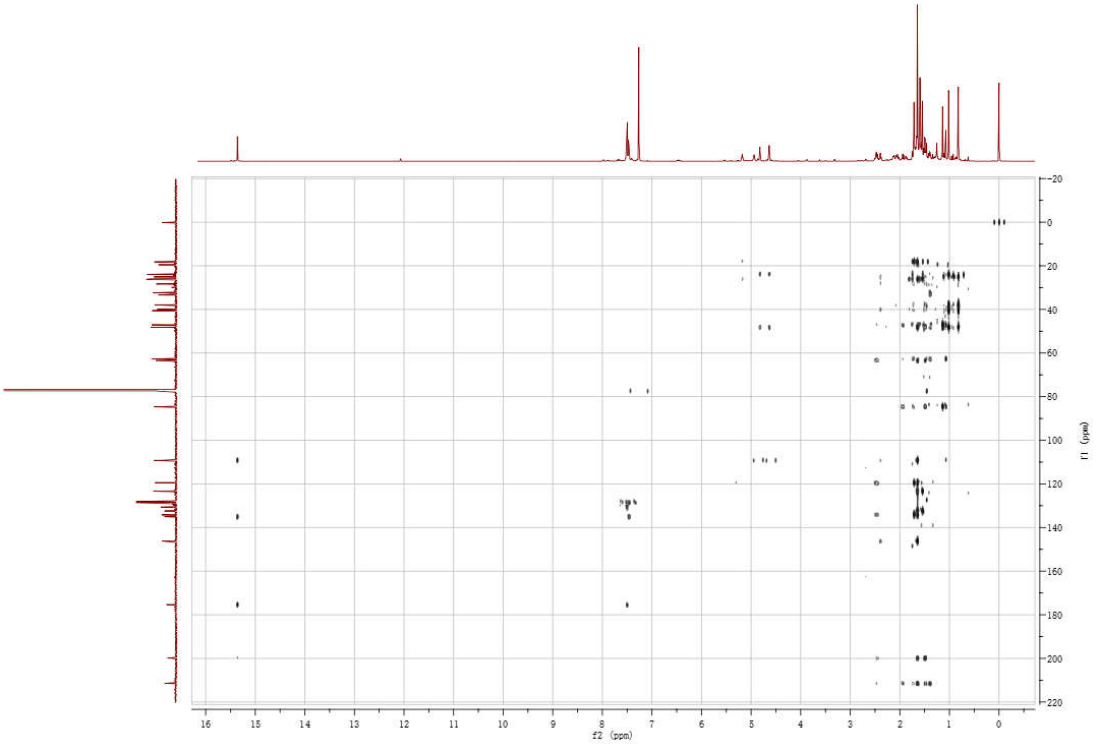

Fig 36. HMBC spectrum of 4

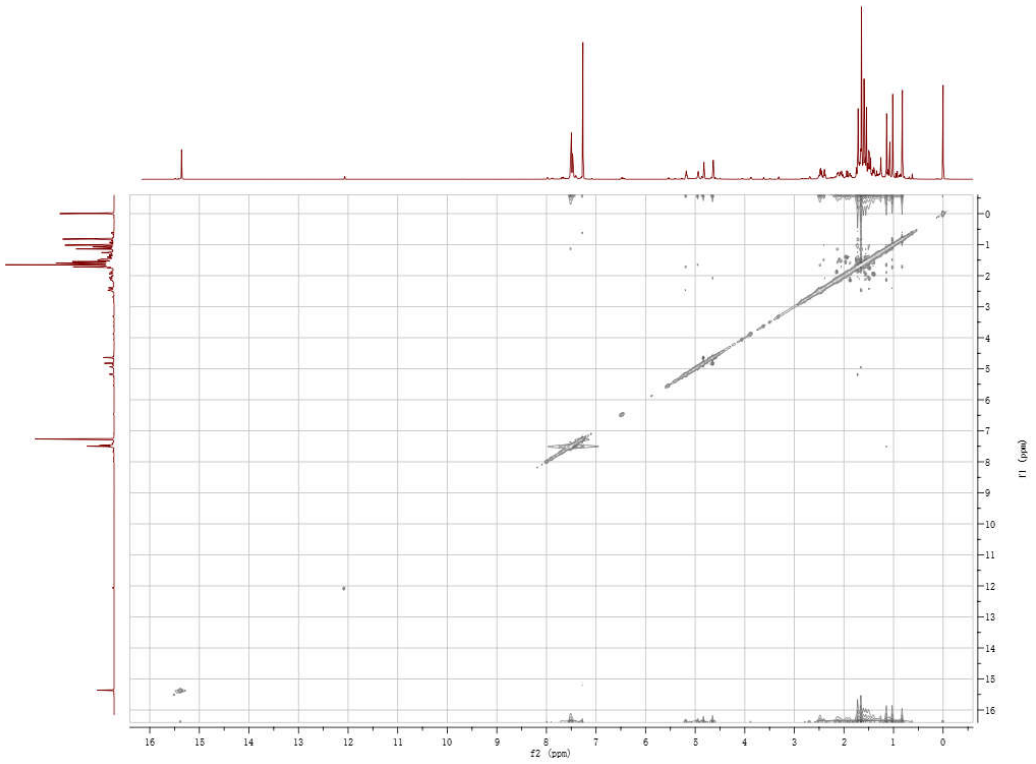

Fig 37. ROESY spectrum of 4

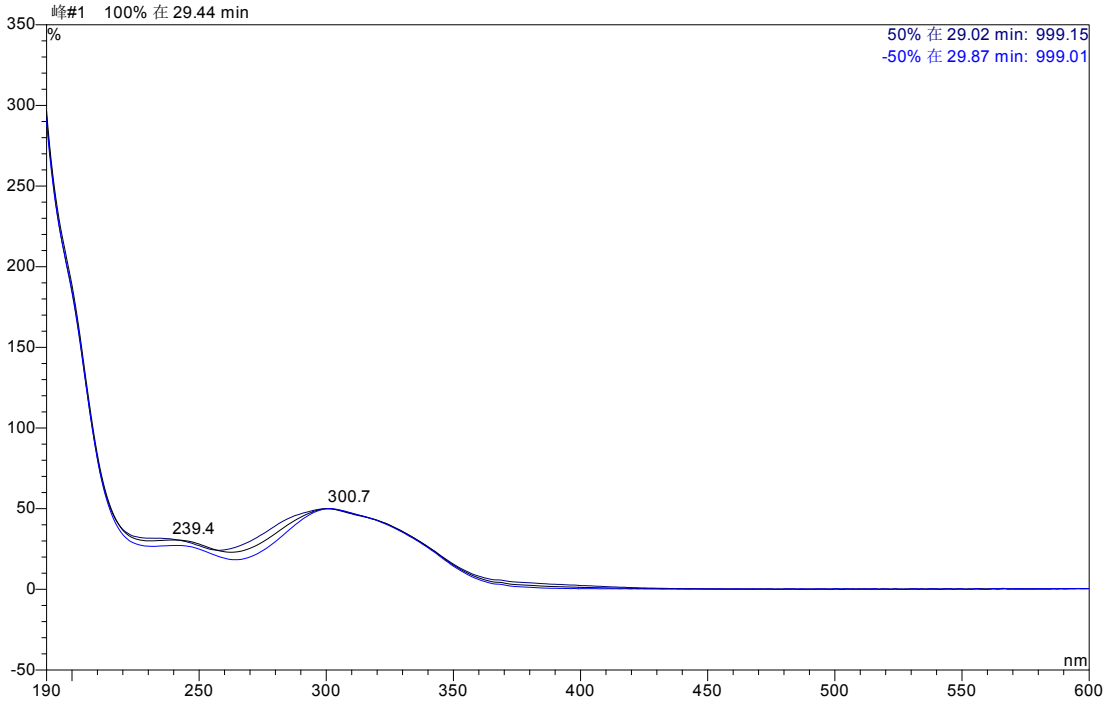

Fig 38. UV spectrum of 4

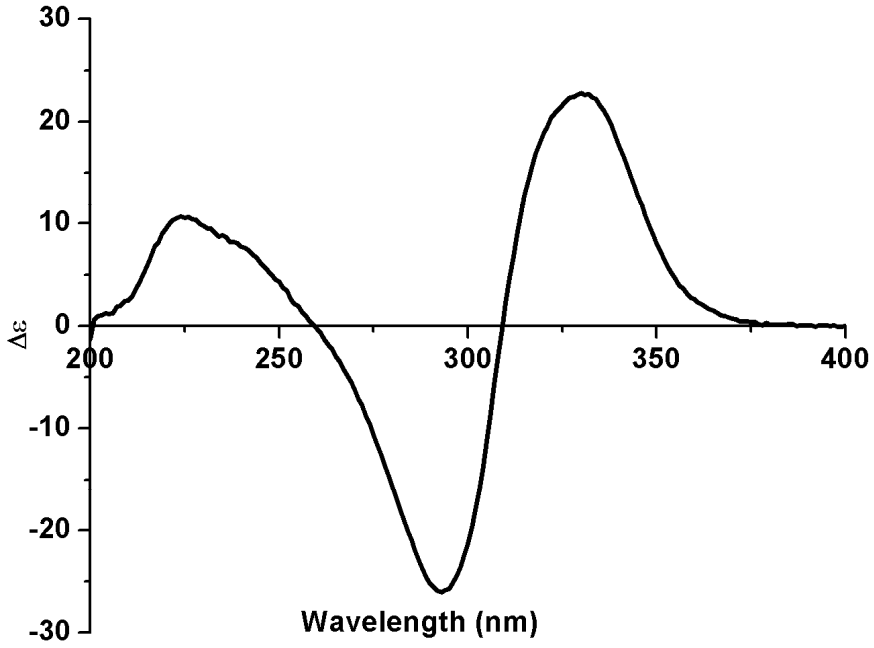

Fig 39. CD spectrum of 4

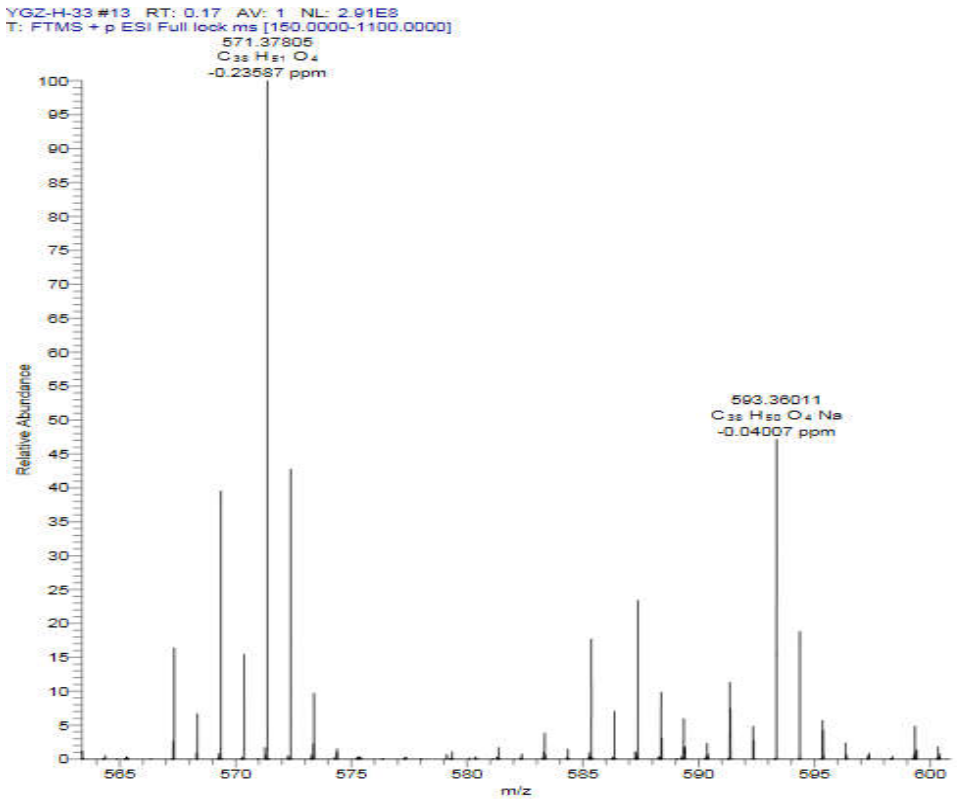

Fig 40. HR-ESI-MS of 4

ECD calculation of 1

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1. Computational methods

1.1 Conformational analysis

Conformational analysis was performed using Confab [1] by systematic search with default settings at MMFF94 force field for all undetermined configurations of compound **1** (**Figure S1**). Room-temperature equilibrium populations were calculated according to Boltzmann distribution law (1) and those with populations lower than 1% were filtered. The energies and populations of dominative conformers were provided in **Table S1**.

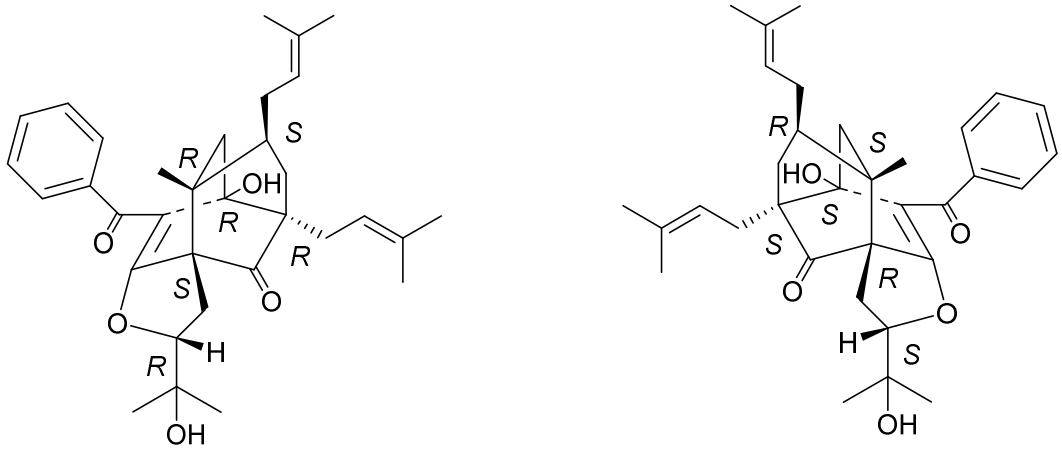


Figure S1 Chemical structure of all undetermined configurations of compound **1**.

$$\frac{N_i}{N} = \frac{g_i e^{-\frac{E_i}{k_B T}}}{\sum g_i e^{-\frac{E_i}{k_B T}}} \qquad \textbf{(1)}$$

where N_i is the number of conformer i with energy E_i and degeneracy g_i at temperature *T*, and k_B is Boltzmann constant.

1.2 ECD calculation

The theoretical calculations were carried out using Gaussian 09 [2]. At first, conformers were optimized at PM6 using semi-empirical theory method and again filtered by Boltzmann-based populations which resulted in only one conformer for each configuration. The remaining structures were finally optimized at B3LYP/6-311G(d,p) in methanol using the IEFPCM model . Vibrational frequency analysis confirmed the stable structures. Based on the optimized structures, the ECD calculation was conducted using Time-dependent Density functional theory (TD-DFT) at the same conditions. Rotatory strengths for a total of 30 excited states were calculated. The ECD spectrum was simulated in SpecDis [3] by overlapping Gaussian functions for each transition according to (2).

$$\Delta\varepsilon(E) = \frac{1}{2.297\times10^{-39}} \times \frac{1}{\sqrt{2\pi\sigma}} \sum_{i}^{A} \Delta E_i R_i e^{-\left(\frac{E-E_i}{2\sigma}\right)^2} \qquad \textbf{(2)}$$

where σ represents the width of the band at $1/e$ height, and ΔE_i and R_i are the excitation energies and rotatory strengths for transition i, respectively.

The values of σ and UV-shift was 0.3 eV and -14 nm for compound **1**.

1.3 References

1. Noel M OBoyle, Tim V, ermeersch, Christopher J Flynn, Anita R Maguire Maguire, and Geoffey R Hutchison. Confab - systematic generation of diverse low-energy conformers. *Journal of Cheminformatics*, 3:8–16, March 2011.
2. M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, B. Mennucci, G. A. Petersson, H. Nakatsuji, M. Caricato, X. Li, H. P. Hratchian, A. F. Izmaylov, J. Bloino, G. Zheng, J. L. Sonnenberg, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, J. A. Montgomery, Jr., J. E. Peralta, F. Ogliaro, M. Bearpark, J. J. Heyd, E. Brothers, K. N. Kudin, V. N. Staroverov, R. Kobayashi, J. Normand, K. Raghavachari, A. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, N. Rega, J. M. Millam, M. Klene, J. E. Knox, J. B. Cross, V. Bakken, C. Adamo, J. Jaramillo, R. Gomperts, R. E. Stratmann, O. Yazyev, A. J. Austin, R. Cammi, C. Pomelli, J. W. Ochterski, R. L. Martin, K. Morokuma, V. G. Zakrzewski, G. A. Voth, P. Salvador, J. J.

Dannenberg, S. Dapprich, A. D. Daniels, O. Farkas, J. B. Foresman, J. V. Ortiz, J. Cioslowski, and D. J. Fox. Gaussian 09 Revision D.01. Gaussian Inc. Wallingford CT 2009.

3. Torsten Bruhn, Anu Schaumlffl, Anu Schaumlffl, Yasmin Hemberger, Yasmin Hemberger, Gerhard Bringmann, and Gerhard Bringmann. Specdis: quantifying the comparison of calculated and experimental electronic circular dichroism spectra. *Chirality*, 25(4):243–9, April 2013.
4. Michael W. Lodewyk, Matthew R. Siebert, and Dean J. Tantillo. Computational Prediction of 1H and 13C Chemical Shifts: A Useful Tool for Natural Product, Mechanistic, and Synthetic Organic Chemistry. *Chem. Rev.*, **2012**, *112* (3), pp 1839–1862.

2. Energies and Coordinates

2.1 Energies at MMFF94 force field

Systematic conformational search was performed by Confab program at MMFF94 force field. Conformers for each configuration were obtained with filtration by RMSD threshold of 0.5 Å.

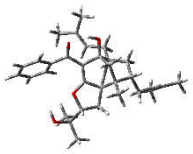
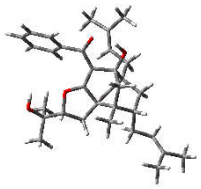
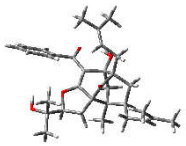
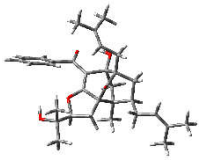
Table S1 Energies of configurations of compound **1** at MMFF94 force field.

Configuration	Conformer	Energy (kcal/mol)	Population (%)
1a	1	166.91	72.21
1a	2	167.93	12.98
1a	3	167.99	11.75
1a	4	169.39	1.11
1b	1	166.23	90.23
1b	2	168.29	2.75
1b	3	168.70	1.38
1b	4	168.76	1.25
1b	5	168.80	1.17

2.2 Energies at B3LYP theory level

Structures for ECD calculations were optimized at B3LYP/6-311G(d,p) in methanol.

Table S2 Energies of compound **1** at B3LYP/6-311G(d,p) in methanol.

Configuration	Conformer	Structure	E (Hartree)	E (kcal/mol)	Population (%)
1a	1		-1659.32690334	-1041243.34	83.57
1a	3		-1659.32536723	-1041242.38	16.43
1b	1		-1659.32690334	-1041243.34	83.57
1b	3		-1659.32536723	-1041242.38	16.43

2.3 Coordinates at B3LYP theory level

Table S3 Standard orientations of compound **1** at B3LYP/6-311G(d,p) level in methanol.

Conformer 1a-1

Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms)		
			X	Y	Z
1	6	0	0.666515	0.620375	0.616112
2	6	0	-0.808461	0.950409	0.493500
3	6	0	-1.164166	-0.081892	-0.597291
4	6	0	1.011638	-0.667659	0.891850
5	6	0	-1.278237	-1.451218	0.041612
6	6	0	-0.260767	-1.477557	1.260167
7	6	0	-1.643051	0.522094	1.799559
8	6	0	-0.901581	-0.677825	2.422199
9	1	0	-1.603689	-1.308902	2.971356
10	1	0	-0.121510	-0.367515	3.120894
11	6	0	-2.739816	-1.407535	0.595465
12	1	0	-3.440662	-1.527869	-0.232769
13	1	0	-2.877454	-2.268204	1.254078

14	6	0	-3.018372	-0.068227	1.351405
15	1	0	-3.553070	-0.306396	2.276948
16	6	0	2.351984	-1.179119	1.158337
17	6	0	3.567303	-0.542925	0.561775
18	6	0	3.583626	-0.050512	-0.748084
19	1	0	2.682832	-0.087375	-1.347386
20	6	0	4.760648	0.458081	-1.291452
21	1	0	4.769842	0.821360	-2.312523
22	6	0	5.925244	0.497313	-0.524568
23	1	0	6.837949	0.903247	-0.945720
24	6	0	5.916507	0.006632	0.781848
25	1	0	6.820706	0.033840	1.378881
26	6	0	4.747975	-0.525481	1.316314
27	1	0	4.734833	-0.927424	2.321910
28	8	0	2.513006	-2.163377	1.899339
29	6	0	-3.924809	0.900227	0.552028
30	1	0	-3.979465	1.849035	1.098750
31	1	0	-3.486219	1.131110	-0.419762
32	6	0	-5.326085	0.372150	0.393779
33	1	0	-5.844850	0.192551	1.335529
34	6	0	-5.998540	0.109588	-0.734934
35	6	0	-1.093039	-2.614447	-0.951557
36	1	0	-1.300203	-3.542746	-0.420508
37	1	0	-1.874495	-2.500760	-1.712268
38	6	0	0.238117	-2.668651	-1.654507
39	1	0	0.438538	-1.820549	-2.305966
40	8	0	-1.346571	0.188665	-1.763596
41	8	0	1.443107	1.675395	0.373829
42	6	0	0.628552	2.899569	0.272313
43	1	0	0.714986	3.388088	1.246000
44	6	0	-0.804498	2.408515	0.015504
45	1	0	-1.525696	3.030798	0.538859
46	1	0	-1.044620	2.427373	-1.048221
47	6	0	1.295497	3.820902	-0.765208
48	6	0	1.348863	3.214064	-2.172295
49	1	0	0.354755	3.061515	-2.596966
50	1	0	1.868294	2.253609	-2.163814
51	1	0	1.897871	3.894033	-2.826520
52	6	0	0.585915	5.174201	-0.768330
53	1	0	-0.440829	5.083653	-1.128377
54	1	0	1.122742	5.860090	-1.426730
55	1	0	0.570863	5.604241	0.235963
56	6	0	-1.778014	1.660867	2.812222
57	1	0	-2.263273	1.285260	3.717511

58	1	0	-2.375248	2.496547	2.443292
59	1	0	-0.796766	2.047032	3.102430
60	6	0	-5.451804	0.292101	-2.129335
61	1	0	-5.564625	-0.633670	-2.704740
62	1	0	-4.399630	0.573583	-2.149791
63	1	0	-6.020029	1.060886	-2.666293
64	6	0	-7.419167	-0.400080	-0.685827
65	1	0	-8.096673	0.279980	-1.215746
66	1	0	-7.777620	-0.508905	0.339721
67	1	0	-7.503089	-1.372643	-1.184785
68	6	0	1.060285	-4.889954	-0.776157
69	1	0	1.002212	-5.780676	-1.413362
70	1	0	0.205969	-4.882397	-0.102915
71	1	0	1.963948	-5.001885	-0.166152
72	6	0	1.158254	-3.642003	-1.615640
73	6	0	2.411894	-3.551715	-2.452457
74	1	0	2.495983	-4.415303	-3.123126
75	1	0	3.306668	-3.562009	-1.819091
76	1	0	2.432934	-2.644781	-3.059909
77	8	0	-0.021814	-2.816893	1.626432
78	1	0	0.903936	-2.854973	1.936669
79	8	0	2.634269	4.083464	-0.306496
80	1	0	3.097397	3.237386	-0.271508

Conformer 1a-3

Center	Atomic	Atomic	Coordinates (Angstroms)		
Number	Number	Type	X	Y	Z
1	6	0	0.594594	0.609193	0.500740
2	6	0	-0.873871	0.771477	0.157089
3	6	0	-0.947310	-0.296292	-0.954171
4	6	0	1.034238	-0.630847	0.850121
5	6	0	-1.003114	-1.668160	-0.312526
6	6	0	-0.180454	-1.577934	1.041237
7	6	0	-1.838105	0.256049	1.335770
8	6	0	-1.070536	-0.854109	2.082123
9	1	0	-1.773234	-1.558290	2.532942
10	1	0	-0.442242	-0.457879	2.882951
11	6	0	-2.527648	-1.784962	0.019521
12	1	0	-3.069961	-1.989229	-0.905166
13	1	0	-2.668086	-2.654628	0.665461
14	6	0	-3.062249	-0.483520	0.705367
15	1	0	-3.694648	-0.781491	1.547426
16	6	0	2.367794	-0.986530	1.324856
17	6	0	3.579791	-0.228401	0.885520
18	6	0	3.724292	0.249304	-0.421871

19	1	0	2.925558	0.103753	-1.137973
20	6	0	4.901217	0.883727	-0.811024
21	1	0	5.011921	1.236330	-1.829880
22	6	0	5.935893	1.062217	0.107448
23	1	0	6.847610	1.565076	-0.194293
24	6	0	5.799683	0.585966	1.412179
25	1	0	6.603217	0.721320	2.126864
26	6	0	4.634166	-0.069589	1.794611
27	1	0	4.524697	-0.458610	2.799460
28	8	0	2.521821	-1.932190	2.115338
29	6	0	-3.949514	0.386849	-0.221868
30	1	0	-4.146089	1.339983	0.271042
31	1	0	-3.407187	0.622939	-1.144209
32	6	0	-5.248885	-0.282725	-0.590564
33	1	0	-5.157843	-1.130614	-1.267054
34	6	0	-6.486377	0.035152	-0.186524
35	6	0	-0.547811	-2.805695	-1.246052
36	1	0	-0.720695	-3.750139	-0.731532
37	1	0	-1.221133	-2.785818	-2.111532
38	6	0	0.866475	-2.707925	-1.755187
39	1	0	1.061331	-1.839293	-2.380850
40	8	0	-0.983545	-0.052127	-2.139469
41	8	0	1.277544	1.743973	0.354221
42	6	0	0.355805	2.868785	0.110687
43	1	0	0.242968	3.366422	1.076946
44	6	0	-0.960305	2.219258	-0.343633
45	1	0	-1.815375	2.758231	0.055715
46	1	0	-1.041740	2.207176	-1.431210
47	6	0	1.062704	3.855527	-0.836394
48	6	0	1.384077	3.254360	-2.209921
49	1	0	0.483655	3.014354	-2.778561
50	1	0	1.977861	2.343660	-2.108021
51	1	0	1.964625	3.980449	-2.782167
52	6	0	0.219494	5.123404	-0.965527
53	1	0	-0.733440	4.918795	-1.457362
54	1	0	0.763992	5.858883	-1.561118
55	1	0	0.022488	5.556434	0.018095
56	6	0	-2.239136	1.373972	2.299632
57	1	0	-2.811331	0.949536	3.129376
58	1	0	-2.857270	2.144317	1.835688
59	1	0	-1.356731	1.860193	2.725110
60	6	0	-6.830397	1.169749	0.745961
61	1	0	-7.514089	1.873267	0.256668
62	1	0	-5.961501	1.728992	1.091320

63	1	0	-7.358130	0.789525	1.628192
64	6	0	-7.679953	-0.757968	-0.662928
65	1	0	-8.225409	-1.190614	0.184075
66	1	0	-7.388250	-1.569009	-1.333033
67	1	0	-8.391316	-0.113509	-1.192963
68	6	0	1.796102	-4.830856	-0.749781
69	1	0	1.936395	-5.718775	-1.377994
70	1	0	0.856502	-4.927087	-0.210257
71	1	0	2.606514	-4.840110	-0.011921
72	6	0	1.872597	-3.575445	-1.580385
73	6	0	3.212619	-3.344717	-2.237050
74	1	0	3.479757	-4.188714	-2.884352
75	1	0	4.008050	-3.264925	-1.486833
76	1	0	3.219783	-2.435708	-2.841634
77	8	0	0.151362	-2.881874	1.459351
78	1	0	1.002479	-2.808616	1.933133
79	8	0	2.284517	4.263896	-0.194932
80	1	0	2.827429	3.474113	-0.081381

Conformer 1b-1

Center	Atomic	Atomic	Coordinates (Angstroms)		
Number	Number	Type	X	Y	Z
1	6	0	-0.666515	0.620375	0.616112
2	6	0	0.808461	0.950409	0.493500
3	6	0	1.164166	-0.081892	-0.597291
4	6	0	-1.011638	-0.667659	0.891850
5	6	0	1.278237	-1.451218	0.041612
6	6	0	0.260767	-1.477557	1.260167
7	6	0	1.643051	0.522094	1.799559
8	6	0	0.901581	-0.677825	2.422199
9	1	0	1.603689	-1.308902	2.971356
10	1	0	0.121510	-0.367515	3.120894
11	6	0	2.739816	-1.407535	0.595465
12	1	0	3.440662	-1.527869	-0.232769
13	1	0	2.877454	-2.268204	1.254078
14	6	0	3.018372	-0.068227	1.351405
15	1	0	3.553070	-0.306396	2.276948
16	6	0	-2.351984	-1.179119	1.158337
17	6	0	-3.567303	-0.542925	0.561775
18	6	0	-3.583626	-0.050512	-0.748084
19	1	0	-2.682832	-0.087375	-1.347386
20	6	0	-4.760648	0.458081	-1.291452
21	1	0	-4.769842	0.821360	-2.312523
22	6	0	-5.925244	0.497313	-0.524568
23	1	0	-6.837949	0.903247	-0.945720

24	6	0	-5.916507	0.006632	0.781848
25	1	0	-6.820706	0.033840	1.378881
26	6	0	-4.747975	-0.525481	1.316314
27	1	0	-4.734833	-0.927424	2.321910
28	8	0	-2.513006	-2.163377	1.899339
29	6	0	3.924809	0.900227	0.552028
30	1	0	3.979465	1.849035	1.098750
31	1	0	3.486219	1.131110	-0.419762
32	6	0	5.326085	0.372150	0.393779
33	1	0	5.844850	0.192551	1.335529
34	6	0	5.998540	0.109588	-0.734934
35	6	0	1.093039	-2.614447	-0.951557
36	1	0	1.300203	-3.542746	-0.420508
37	1	0	1.874495	-2.500760	-1.712268
38	6	0	-0.238117	-2.668651	-1.654507
39	1	0	-0.438538	-1.820549	-2.305966
40	8	0	1.346571	0.188665	-1.763596
41	8	0	-1.443107	1.675395	0.373829
42	6	0	-0.628552	2.899569	0.272313
43	1	0	-0.714986	3.388088	1.246000
44	6	0	0.804498	2.408515	0.015504
45	1	0	1.525696	3.030798	0.538859
46	1	0	1.044620	2.427373	-1.048221
47	6	0	-1.295497	3.820902	-0.765208
48	6	0	-1.348863	3.214064	-2.172295
49	1	0	-0.354755	3.061515	-2.596966
50	1	0	-1.868294	2.253609	-2.163814
51	1	0	-1.897871	3.894033	-2.826520
52	6	0	-0.585915	5.174201	-0.768330
53	1	0	0.440829	5.083653	-1.128377
54	1	0	-1.122742	5.860090	-1.426730
55	1	0	-0.570863	5.604241	0.235963
56	6	0	1.778014	1.660867	2.812222
57	1	0	2.263273	1.285260	3.717511
58	1	0	2.375248	2.496547	2.443292
59	1	0	0.796766	2.047032	3.102430
60	6	0	5.451804	0.292101	-2.129335
61	1	0	5.564625	-0.633670	-2.704740
62	1	0	4.399630	0.573583	-2.149791
63	1	0	6.020029	1.060886	-2.666293
64	6	0	7.419167	-0.400080	-0.685827
65	1	0	8.096673	0.279980	-1.215746
66	1	0	7.777620	-0.508905	0.339721
67	1	0	7.503089	-1.372643	-1.184785

68	6	0	-1.060285	-4.889954	-0.776157
69	1	0	-1.002212	-5.780676	-1.413362
70	1	0	-0.205969	-4.882397	-0.102915
71	1	0	-1.963948	-5.001885	-0.166152
72	6	0	-1.158254	-3.642003	-1.615640
73	6	0	-2.411894	-3.551715	-2.452457
74	1	0	-2.495983	-4.415303	-3.123126
75	1	0	-3.306668	-3.562009	-1.819091
76	1	0	-2.432934	-2.644781	-3.059909
77	8	0	0.021814	-2.816893	1.626432
78	1	0	-0.903936	-2.854973	1.936669
79	8	0	-2.634269	4.083464	-0.306496
80	1	0	-3.097397	3.237386	-0.271508

Conformer 1b-3

Center	Atomic	Atomic	Coordinates (Angstroms)		
Number	Number	Type	X	Y	Z
1	6	0	-0.594594	0.609193	0.500740
2	6	0	0.873871	0.771477	0.157089
3	6	0	0.947310	-0.296292	-0.954171
4	6	0	-1.034238	-0.630847	0.850121
5	6	0	1.003114	-1.668160	-0.312526
6	6	0	0.180454	-1.577934	1.041237
7	6	0	1.838105	0.256049	1.335770
8	6	0	1.070536	-0.854109	2.082123
9	1	0	1.773234	-1.558290	2.532942
10	1	0	0.442242	-0.457879	2.882951
11	6	0	2.527648	-1.784962	0.019521
12	1	0	3.069961	-1.989229	-0.905166
13	1	0	2.668086	-2.654628	0.665461
14	6	0	3.062249	-0.483520	0.705367
15	1	0	3.694648	-0.781491	1.547426
16	6	0	-2.367794	-0.986530	1.324856
17	6	0	-3.579791	-0.228401	0.885520
18	6	0	-3.724292	0.249304	-0.421871
19	1	0	-2.925558	0.103753	-1.137973
20	6	0	-4.901217	0.883727	-0.811024
21	1	0	-5.011921	1.236330	-1.829880
22	6	0	-5.935893	1.062217	0.107448
23	1	0	-6.847610	1.565076	-0.194293
24	6	0	-5.799683	0.585966	1.412179
25	1	0	-6.603217	0.721320	2.126864
26	6	0	-4.634166	-0.069589	1.794611
27	1	0	-4.524697	-0.458610	2.799460
28	8	0	-2.521821	-1.932190	2.115338

29	6	0	3.949514	0.386849	-0.221868
30	1	0	4.146089	1.339983	0.271042
31	1	0	3.407187	0.622939	-1.144209
32	6	0	5.248885	-0.282725	-0.590564
33	1	0	5.157843	-1.130614	-1.267054
34	6	0	6.486377	0.035152	-0.186524
35	6	0	0.547811	-2.805695	-1.246052
36	1	0	0.720695	-3.750139	-0.731532
37	1	0	1.221133	-2.785818	-2.111532
38	6	0	-0.866475	-2.707925	-1.755187
39	1	0	-1.061331	-1.839293	-2.380850
40	8	0	0.983545	-0.052127	-2.139469
41	8	0	-1.277544	1.743973	0.354221
42	6	0	-0.355805	2.868785	0.110687
43	1	0	-0.242968	3.366422	1.076946
44	6	0	0.960305	2.219258	-0.343633
45	1	0	1.815375	2.758231	0.055715
46	1	0	1.041740	2.207176	-1.431210
47	6	0	-1.062704	3.855527	-0.836394
48	6	0	-1.384077	3.254360	-2.209921
49	1	0	-0.483655	3.014354	-2.778561
50	1	0	-1.977861	2.343660	-2.108021
51	1	0	-1.964625	3.980449	-2.782167
52	6	0	-0.219494	5.123404	-0.965527
53	1	0	0.733440	4.918795	-1.457362
54	1	0	-0.763992	5.858883	-1.561118
55	1	0	-0.022488	5.556434	0.018095
56	6	0	2.239136	1.373972	2.299632
57	1	0	2.811331	0.949536	3.129376
58	1	0	2.857270	2.144317	1.835688
59	1	0	1.356731	1.860193	2.725110
60	6	0	6.830397	1.169749	0.745961
61	1	0	7.514089	1.873267	0.256668
62	1	0	5.961501	1.728992	1.091320
63	1	0	7.358130	0.789525	1.628192
64	6	0	7.679953	-0.757968	-0.662928
65	1	0	8.225409	-1.190614	0.184075
66	1	0	7.388250	-1.569009	-1.333033
67	1	0	8.391316	-0.113509	-1.192963
68	6	0	-1.796102	-4.830856	-0.749781
69	1	0	-1.936395	-5.718775	-1.377994
70	1	0	-0.856502	-4.927087	-0.210257
71	1	0	-2.606514	-4.840110	-0.011921
72	6	0	-1.872597	-3.575445	-1.580385

73	6	0	-3.212619	-3.344717	-2.237050
74	1	0	-3.479757	-4.188714	-2.884352
75	1	0	-4.008050	-3.264925	-1.486833
76	1	0	-3.219783	-2.435708	-2.841634
77	8	0	-0.151362	-2.881874	1.459351
78	1	0	-1.002479	-2.808616	1.933133
79	8	0	-2.284517	4.263896	-0.194932
80	1	0	-2.827429	3.474113	-0.081381

3. Experimental and calculated ECD spectra

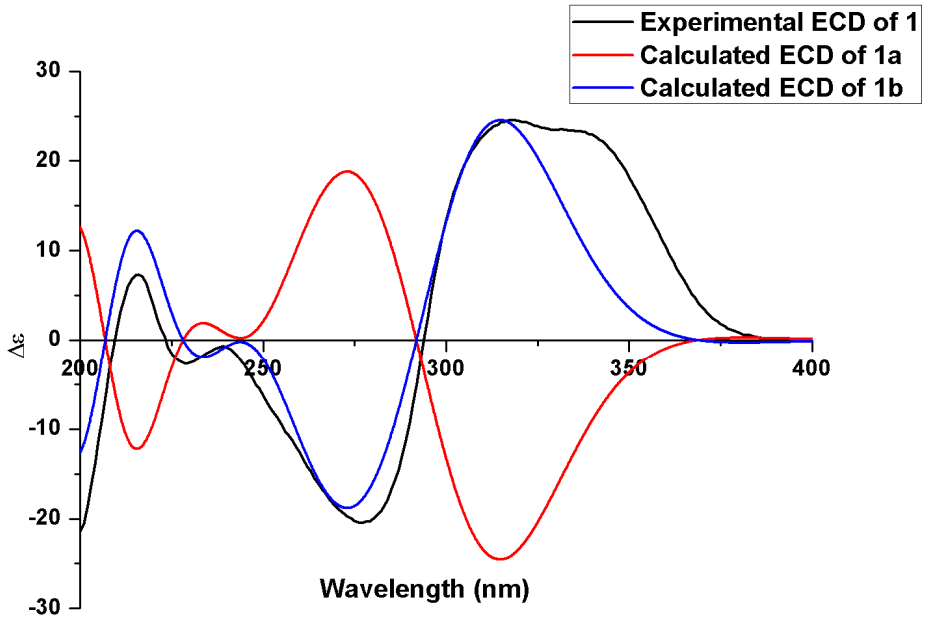


Figure S2 Calculated ECD spectra of compound **1** was compared with the experimental.

NMR calculation of 1

Contents Page

1 Computational methods

1.1NMR calculation

NMR calculations were carried out by Gaussian 09 following the protocol adapted from Michael *et al*. [1] (**Table S2**). Structures of were derived from previous ECD calculations and the NMR calculations were conducted using the Gauge-Including Atomic Orbitals (GIAO) method at mPW1PW91/6-311+G(2d,p) in chloroform by the IEFPCM model. Finally, the TMS-corrected NMR chemical shift values were fitted to the experimental values by Ordinary Least Squares Linear Regression (OLSLR) method. The calculated ^{13}C- and ^{1}H-NMR chemical shift values of TMS in chloroform was 187.18 and 31.73 ppm, respectively.

References

1 Michael W. Lodewyk, Matthew R. Siebert, and Dean J. Tantillo. Computational Prediction of 1H and 13C Chemical Shifts: A Useful Tool for Natural Product, Mechanistic, and Synthetic Organic Chemistry. *Chem. Rev.*, 2012, *112* (3), pp 1839–1862.

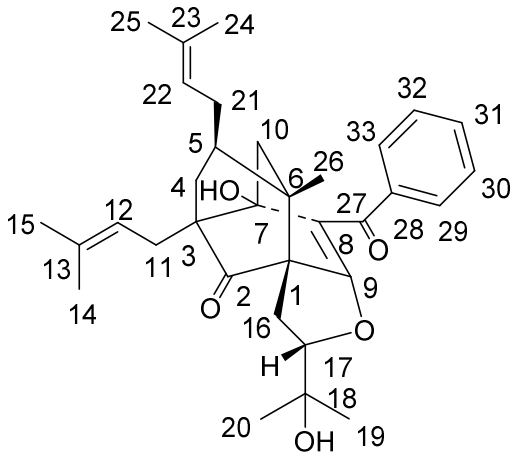
2 Experimental and Computed NMR Chemical Shifts

2.1 ^{13}C- and ^{1}H-NMR chemical shifts

The TMS-corrected computed NMR chemical shifts for each conformer were fitted to the experimental values by Ordinary Least Squares (OLS) linear regression method in order to remove systematic error that results from the conformational search and random error from experimental conditions (**Table S**4).

Configurations 1a and 1b have the same NMR chemical shifts. Significantly high correlations (R^2 > 0.995) were seen in both ^{13}C- and ^{1}H-NMR chemical shifts, confirming the enantiomeric configurations of compound **1** (**Table S5**).

Table S4 Comparison of experimental and computed NMR chemical shifts for compound **1**.



^{13}C-NMR chemical shifts (ppm)			^{1}H-NMR chemical shifts (ppm)		
Position	Experimental	Calculated	Position	Experimental	Calculated
1	71.1	71.7	4a	**1.63**	**2.10**
2	205.3	205.4	4b	1.58	1.29
3	52.0	53.5	5	1.49	1.51
4	38.0	35.5	10a	2.34	1.99
5	40.3	44.6	10b	1.46	1.67
6	39.7	44.6	11a	2.49	2.66

7	76.7	77.0	11b	2.37	2.16
8	114.1	113.8	12	5.03	5.15
9	163.4	163.8	14	1.63	1.63
10	**48.4**	**54.2**	15	1.33	1.41
11	28.5	29.4	16a	2.82	2.67
12	119.5	119.2	16b	1.92	1.80
13	134.3	137.4	17	4.30	4.24
14	18.2	16.9	19	1.00	1.07
15	26.4	25.3	20	1.13	1.25
16	20.6	23.1	21a	2.12	2.00
17	96.3	97.5	21b	1.90	1.72
18	71.6	72.4	22	4.98	5.05
19	25.9	21.8	24	1.62	1.64
20	24.7	19.8	25	1.69	1.77
21	28.3	28.6	26	0.99	1.09
22	121.5	122.7	29	7.56	7.56
23	133.6	136.8	30	7.38	7.33
24	18.0	16.6	31	7.48	7.48
25	26.0	25.1	32	7.38	7.33
26	21.2	19.0	33	7.56	7.56
27	194.0	190.7	OH	6.62	6.65
28	139.7	138.9			
29	128.9	128.2			
30	128.0	125.6			
31	132.2	130.7			
32	128.0	125.6			
33	128.9	128.2			
	CMAD[a]	1.9		CMAD[a]	0.12
	largest outlier[b]	$\Delta\delta = 5.8$		largest outlier[b]	$\Delta\delta = 4.7$

[a] CMAD = corrected mean absolute deviation, computed as $(1/n)\sum_i^n |\delta_{\text{comp}} - \delta_{\text{exp}}|$, where δ_{comp} refers to the scaled computed chemicalshifts. [b] Largest outliers for each set of

data are highlighted in bold text.

Table S5 Statistics of OLS linear regression of experimental and computed NMR chemical shifts for compound **1**.

Type	R^2	RMSE	*F*	*p* value
^{13}C-NMR	0.9981	2.5	15933.51	< 0.01
^{1}H-NMR	0.9954	0.17	5406.45	< 0.01

ECD and NMR calculations of 4

Contents Page

1Computational methods

1.1 Conformational analysis

Conformational analysis was initially performed using Confab [1] with systematic search at MMFF94 force field for configurations a and b of compound **4** (**Figure S1**). Room-temperature equilibrium populations were calculated according to Boltzmann distribution law (1). The energies and populations of dominative conformers (population ≥ 1%) were provided in **Table S6**.

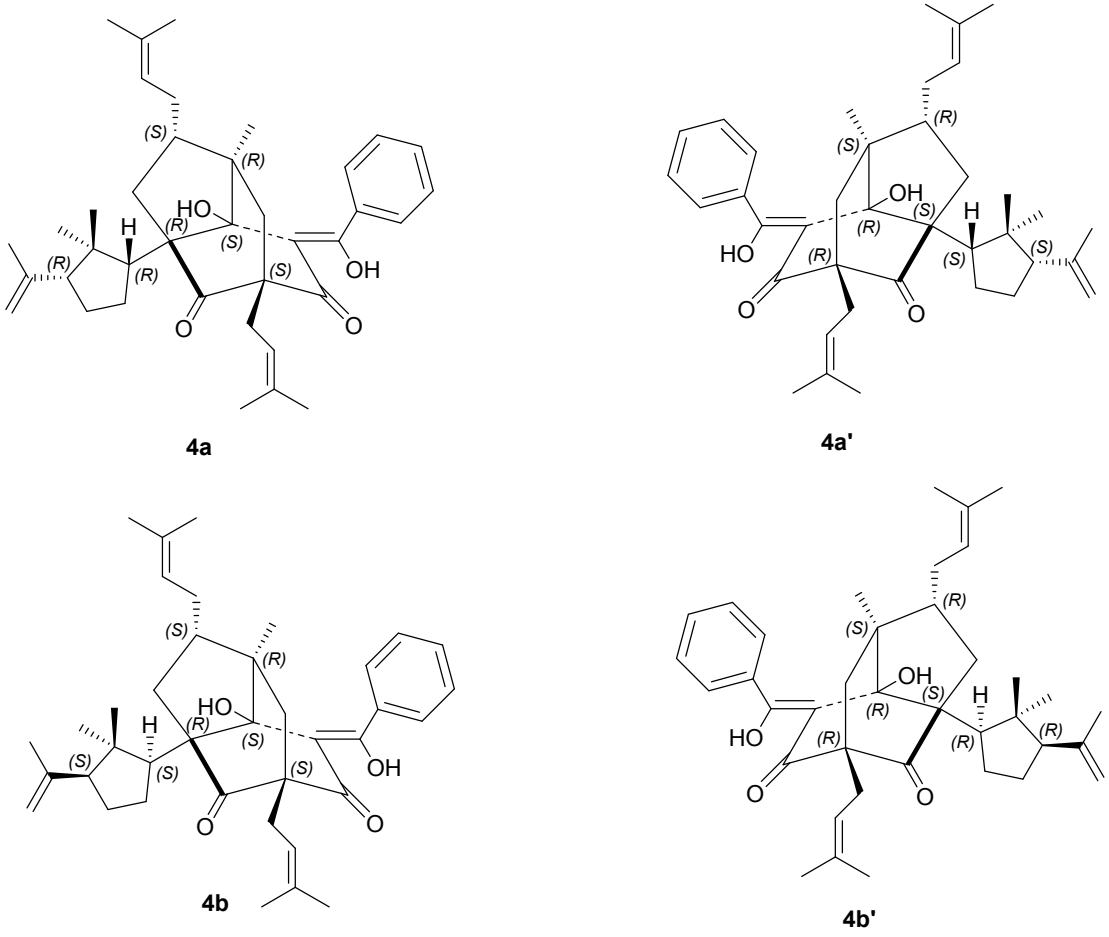


Figure S3 Chemical structure of all undetermined relative configurations of compound **4**.

$$\frac{N_i}{N} = \frac{g_i e^{-\frac{E_i}{k_B T}}}{\sum g_i e^{-\frac{E_i}{k_B T}}} \qquad (3)$$

where N_i is the number of conformer i with energy E_i and degeneracy g_i at temperature *T*, and k_B is Boltzmann constant.

1.2 ECD calculation

The theoretical calculations were carried out using Gaussian 09 [2]. At first, conformers were successively optimized at PM6 and HF/6-31G(d) level and those with Boltzmann-based population over 1% were preserved. The remaining conformers were finally optimized at B3LYP/6-311G(d,p) in gas phase. Vibrational frequency analysis confirmed the stable structures. Under the same theory level, the ECD calculation was conducted using Time-dependent Density functional theory (TD-DFT) in methanol by the IEFPCM model. Rotatory strengths for a total of 30 excited states were calculated. The ECD spectrum was simulated in SpecDis [3] by overlapping Gaussian functions for each transition according to (2).

$$\Delta\varepsilon(E) = \frac{1}{2.297\times10^{-39}} \times \frac{1}{\sqrt{2\pi\sigma}} \sum_{i}^{A} \Delta E_i R_i e^{-\left(\frac{E-E_i}{2\sigma}\right)^2} \qquad \textbf{(4)}$$

where σ represents the width of the band at 1/*e* height, and ΔE_i and R_i are the excitation energies and rotatory strengths for transition *i*, respectively.

Parameters of σ and UV-shift values were set 0.25 eV and -7 nm, respectively. The spectra of the corresponding enantiomers of configurations a and b were obtained directly by mirror inversion operation.

1.3 NMR calculation

NMR calculations were carried out by Gaussian 09 following the protocol adapted from Michael *et al*. [4] (**Table S2**). Conformers were obtained from the previous ECD calculations. The theoretical calculation of NMR was conducted using the Gauge-Including Atomic Orbitals (GIAO) method at mPW1PW91/6-311+G(2d,p) in

chloroform by the IEFPCM model. Finally, the TMS-corrected NMR chemical shift values were averaged according to Boltzmann distribution for each conformer and fitting to the experimental values by linear regression. The calculated ^{13}C- and ^{1}H-NMR chemical shift values of TMS in chloroform was 187.18 and 31.73 ppm, respectively.

1.4 References

3 Noel M OBoyle, Tim V, ermeersch, Christopher J Flynn, Anita R Maguire Maguire, and Geoffey R Hutchison. Confab - systematic generation of diverse low-energy conformers. *Journal of Cheminformatics*, 3:8–16, March 2011.

4 M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, B. Mennucci, G. A. Petersson, H. Nakatsuji, M. Caricato, X. Li, H. P. Hratchian, A. F. Izmaylov,
J. Bloino, G. Zheng, J. L. Sonnenberg, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, J. A. Montgomery, Jr., J. E. Peralta, F. Ogliaro, M. Bearpark, J. J. Heyd, E. Brothers, K. N. Kudin, V. N. Staroverov, R. Kobayashi, J. Normand, K. Raghavachari, A. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, N. Rega, J. M. Millam, M. Klene, J. E. Knox, J. B. Cross, V. Bakken, C. Adamo, J. Jaramillo, R. Gomperts, R. E. Stratmann, O. Yazyev, A. J. Austin, R. Cammi, C. Pomelli, J. W. Ochterski, R. L. Martin, K. Morokuma, V. G. Zakrzewski, G. A. Voth, P. Salvador, J. J. Dannenberg, S. Dapprich, A. D. Daniels, O. Farkas, J. B. Foresman, J. V. Ortiz, J. Cioslowski, and D. J. Fox. Gaussian 09 Revision D.01. Gaussian Inc. Wallingford CT 2009.

5 Torsten Bruhn, Anu Schaumlffl, Anu Schaumlffl, Yasmin Hemberger, Yasmin Hemberger, Gerhard Bringmann, and Gerhard Bringmann. Specdis: quantifying the comparison of calculated and experimental electronic circular dichroism spectra. *Chirality*, 25(4):243–9, April 2013.

6 Michael W. Lodewyk, Matthew R. Siebert, and Dean J. Tantillo. Computational Prediction of 1H and 13C Chemical Shifts: A Useful Tool for Natural Product, Mechanistic, and Synthetic Organic Chemistry. *Chem. Rev.*, 2012, *112* (3), pp 1839–1862.

2. Energies and Coordinates

2.1 Energies at MMFF94 force field

Systematic conformational search was performed by Confab program at MMFF94 force field. Conformers for each configuration were obtained with energy window of

10.0 kcal/mol with RMSD threshold of 0.5 Å. Dominative conformers were preserved.

Table S6 Energies of configurations at MMFF94 force field.

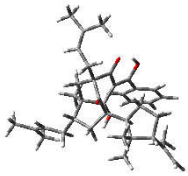
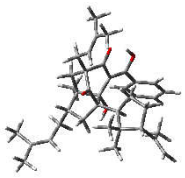
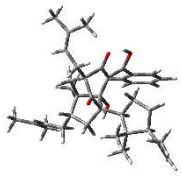
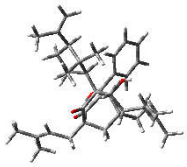
Configuration	Conformer	Energy (kcal/mol)	Population (%)
4a	1	143.93	39.74
4a	2	144.74	10.14
4a	3	144.77	9.64
4a	4	144.98	6.77
4a	5	145.30	3.89
4a	6	145.41	3.27
4a	7	145.47	2.96
4a	8	145.53	2.65
4a	9	145.76	1.80
4a	10	145.79	1.72
4a	11	145.81	1.67
4a	12	146.00	1.21
4a	13	146.00	1.20
4a	14	146.00	1.19
4a	15	146.06	1.09
4a	16	146.11	1.01
4b	1	147.34	64.44
4b	2	148.49	9.28
4b	3	148.74	6.05
4b	4	148.98	4.02
4b	5	149.35	2.16
4b	6	149.54	1.57
4b	7	149.66	1.27
4b	8	149.78	1.05

2.2 Energies at B3LYP theory level

Structures for ECD calculations were optimized at B3LYP/6-311G(d,p) in gas phase.

Table S7 Energies at B3LYP/6-311G(d,p) in gas phase.

Configuration	Conformer	Structure	E (Hartree)	E (kcal/mol)	Population (%)

4a	1		-1779.45765165	-1116626.53	39.29
4a	2		-1779.45806256	-1116626.78	60.71
4b	1		-1779.45938762	-1116627.62	58.69
4b	2		-1779.45905624	-1116627.41	41.31

2.3 Coordinates at B3LYP theory level

Table S8 Standard orientations at B3LYP/6-311G(d,p) level in gas phase.

Conformer 4a-1

Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms)		
			X	Y	Z
1	6	0	-0.928209	-1.873909	0.598332
2	6	0	-0.225611	-0.740407	1.165958
3	6	0	-0.198570	0.442468	0.211378
4	6	0	-1.644641	0.971479	-0.142764
5	6	0	-1.677642	-1.569164	-0.697150
6	6	0	-2.525746	-0.291538	-0.381807
7	1	0	-3.232185	-0.119543	-1.200220
8	1	0	-3.119634	-0.507254	0.511425
9	6	0	0.322424	0.015339	-1.231823
10	6	0	-1.439915	1.742999	-1.510190
11	1	0	-2.209274	1.394063	-2.209118
12	6	0	-0.057117	1.278365	-2.041057
13	1	0	0.693245	2.059316	-1.877405
14	1	0	-0.070710	1.084836	-3.115516
15	6	0	-0.617790	-1.108649	-1.722380

16	8	0	-0.589302	-1.543187	-2.857141
17	6	0	-2.263835	1.797677	0.989391
18	1	0	-3.288052	2.088713	0.739137
19	1	0	-1.701337	2.709283	1.201922
20	1	0	-2.299298	1.202010	1.907679
21	6	0	-1.541350	3.288125	-1.507398
22	1	0	-0.930677	3.714344	-0.703111
23	1	0	-1.071828	3.626702	-2.444547
24	6	0	1.841481	-0.387986	-1.232425
25	8	0	-0.943941	-3.019951	1.100225
26	8	0	0.623916	1.462080	0.759650
27	1	0	0.684438	2.196428	0.135753
28	6	0	-2.637627	5.727376	0.169089
29	1	0	-2.613766	6.770044	-0.174747
30	1	0	-1.604397	5.395332	0.288443
31	1	0	-3.107534	5.738394	1.161532
32	6	0	-3.437118	4.875148	-0.786725
33	6	0	-2.949086	3.829544	-1.475592
34	1	0	-3.639660	3.309330	-2.142608
35	6	0	-4.883036	5.290386	-0.931626
36	1	0	-4.961148	6.327315	-1.284777
37	1	0	-5.402685	5.250511	0.035336
38	1	0	-5.423510	4.650729	-1.635254
39	6	0	-2.511168	-2.753565	-1.226348
40	1	0	-2.759678	-2.516739	-2.268033
41	1	0	-1.867879	-3.634771	-1.262586
42	6	0	-3.784827	-3.036579	-0.470460
43	1	0	-4.533791	-2.245068	-0.517121
44	6	0	-4.130212	-4.151986	0.196128
45	6	0	-5.490209	-4.267655	0.846126
46	1	0	-6.048691	-5.121867	0.439981
47	1	0	-6.093458	-3.366750	0.698793
48	1	0	-5.394487	-4.442971	1.926163
49	6	0	-3.255250	-5.368983	0.365715
50	1	0	-3.119229	-5.591158	1.431991
51	1	0	-2.263953	-5.253134	-0.072108
52	1	0	-3.734970	-6.250224	-0.081538
53	6	0	2.119596	-1.871279	-0.873836
54	1	0	1.906878	-2.084481	0.175341
55	1	0	1.484880	-2.536166	-1.467923
56	6	0	3.608457	-2.119084	-1.214119
57	1	0	3.728064	-3.033183	-1.803412
58	1	0	4.208347	-2.260896	-0.310477
59	6	0	4.106828	-0.884030	-2.024918

60	1	0	4.598640	-1.223622	-2.942133
61	6	0	2.785518	-0.131349	-2.469671
62	6	0	6.369297	0.115027	-1.831514
63	1	0	7.155668	0.659348	-1.314560
64	1	0	6.612270	-0.271355	-2.818045
65	6	0	5.161288	-0.074181	-1.277704
66	6	0	4.868228	0.472387	0.102982
67	1	0	5.774049	0.883440	0.557414
68	1	0	4.474767	-0.298048	0.775601
69	1	0	4.119103	1.271739	0.077741
70	6	0	0.407927	-0.910764	2.392887
71	6	0	1.138086	0.073460	3.235243
72	6	0	0.601536	1.321534	3.582788
73	1	0	-0.354893	1.626336	3.178759
74	6	0	2.365726	-0.320605	3.794823
75	1	0	2.768202	-1.299368	3.556373
76	6	0	3.063568	0.535404	4.646498
77	1	0	4.019935	0.224970	5.057072
78	6	0	2.525996	1.781510	4.980453
79	1	0	3.062198	2.444534	5.653430
80	6	0	1.289294	2.165850	4.454442
81	1	0	0.856944	3.124911	4.724839
82	8	0	0.413992	-2.117607	2.962930
83	1	0	-0.092868	-2.744674	2.346492
84	6	0	3.072187	1.347477	-2.793242
85	1	0	3.976511	1.424073	-3.406240
86	1	0	3.240869	1.952017	-1.895997
87	1	0	2.259465	1.803454	-3.364162
88	6	0	2.297449	-0.815506	-3.765916
89	1	0	1.337305	-0.420298	-4.102526
90	1	0	2.169754	-1.894979	-3.646607
91	1	0	3.033312	-0.652247	-4.562190
92	1	0	2.261877	0.219952	-0.425013

Conformer 4a-2

Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms)		
			X	Y	Z
1	6	0	1.275803	1.608308	-1.213125
2	6	0	1.035071	0.197513	-1.444164
3	6	0	-0.323227	-0.240509	-0.925906
4	6	0	-1.506678	0.552412	-1.613843
5	6	0	0.085389	2.373280	-0.640823
6	6	0	-1.069729	2.050603	-1.657733
7	1	0	-1.917801	2.709667	-1.447321
8	1	0	-0.703613	2.309241	-2.657683

9	6	0	-0.547556	0.170263	0.592834
10	6	0	-2.711993	0.377097	-0.601728
11	1	0	-3.160326	1.362693	-0.434347
12	6	0	-2.066984	-0.101143	0.729360
13	1	0	-2.241229	-1.173207	0.873447
14	1	0	-2.487940	0.400907	1.601380
15	6	0	-0.390425	1.704798	0.660083
16	8	0	-0.747182	2.357737	1.622239
17	6	0	-1.789387	0.076139	-3.042856
18	1	0	-2.573611	0.685278	-3.506649
19	1	0	-2.104020	-0.968967	-3.081202
20	1	0	-0.889027	0.180193	-3.657262
21	6	0	-3.874673	-0.538125	-1.059397
22	1	0	-4.237315	-0.206200	-2.035138
23	1	0	-3.501785	-1.563726	-1.208320
24	6	0	0.405550	-0.605470	1.572304
25	8	0	2.338029	2.198282	-1.510697
26	8	0	-0.454115	-1.643923	-1.089002
27	1	0	-1.291458	-1.933250	-0.705320
28	6	0	-7.257355	-0.206417	0.919154
29	1	0	-6.844352	-0.731034	1.785420
30	1	0	-8.147606	-0.753373	0.580717
31	1	0	-7.605005	0.780819	1.251534
32	6	0	-6.247084	-0.076343	-0.197343
33	6	0	-5.006440	-0.578589	-0.063683
34	1	0	-4.775081	-1.072131	0.880719
35	6	0	-6.764688	0.644755	-1.419194
36	1	0	-6.030831	0.725037	-2.223455
37	1	0	-7.086270	1.661021	-1.155633
38	1	0	-7.649755	0.133891	-1.820810
39	6	0	0.315943	3.892738	-0.510780
40	1	0	0.575617	4.273514	-1.502190
41	1	0	-0.656056	4.329645	-0.246227
42	6	0	1.322832	4.334772	0.523405
43	1	0	1.056797	4.077867	1.546304
44	6	0	2.449210	5.042386	0.332839
45	6	0	2.981247	5.494805	-1.003976
46	1	0	3.986675	5.085838	-1.168274
47	1	0	3.076793	6.588830	-1.030940
48	1	0	2.361811	5.182844	-1.845451
49	6	0	3.307372	5.444971	1.510534
50	1	0	2.887265	5.098666	2.459360
51	1	0	3.416248	6.536846	1.564199
52	1	0	4.321960	5.034708	1.414392

53	6	0	1.800165	0.046005	1.766342
54	1	0	2.416746	-0.037784	0.869324
55	1	0	1.701162	1.114625	1.981302
56	6	0	2.445590	-0.678348	2.971665
57	1	0	2.847839	0.041661	3.690690
58	1	0	3.291062	-1.298598	2.660464
59	6	0	1.333471	-1.544410	3.637905
60	1	0	1.306822	-1.341135	4.713282
61	6	0	-0.023981	-0.990463	3.038902
62	6	0	1.671415	-3.795270	4.624658
63	1	0	1.888479	-4.859466	4.578067
64	1	0	1.521541	-3.371482	5.614411
65	6	0	1.597576	-3.041607	3.516355
66	6	0	1.826368	-3.668585	2.158150
67	1	0	2.146410	-4.709364	2.260067
68	1	0	2.594109	-3.136055	1.585441
69	1	0	0.920123	-3.660420	1.542363
70	6	0	2.049663	-0.552445	-2.029227
71	6	0	2.072176	-1.987671	-2.423552
72	6	0	1.109210	-2.557426	-3.268023
73	1	0	0.267571	-1.964142	-3.601557
74	6	0	3.174069	-2.762701	-2.024778
75	1	0	3.940323	-2.315833	-1.399945
76	6	0	3.285263	-4.094479	-2.424381
77	1	0	4.132990	-4.687155	-2.093161
78	6	0	2.316356	-4.657813	-3.259243
79	1	0	2.407571	-5.691179	-3.581377
80	6	0	1.235531	-3.881926	-3.687374
81	1	0	0.488368	-4.307861	-4.350825
82	8	0	3.222824	0.025762	-2.293441
83	1	0	3.142282	1.002524	-2.027573
84	6	0	-1.146267	-2.040059	3.143919
85	1	0	-1.141758	-2.490861	4.142006
86	1	0	-1.028828	-2.854973	2.422051
87	1	0	-2.133623	-1.594721	2.998030
88	6	0	-0.426303	0.230294	3.896154
89	1	0	0.372788	0.974569	3.960051
90	1	0	-0.656561	-0.099902	4.915987
91	1	0	-1.303209	0.741273	3.495218
92	1	0	0.566256	-1.560243	1.061023

Conformer 4b-1

Center	Atomic	Atomic	Coordinates (Angstroms)		
Number	Number	Type	X	Y	Z
1	6	0	0.601227	1.932196	0.706838

2	6	0	0.388260	0.629590	1.304845
3	6	0	0.431415	-0.482280	0.268388
4	6	0	1.828299	-0.571380	-0.466739
5	6	0	1.048982	1.892309	-0.753730
6	6	0	2.255449	0.894706	-0.775188
7	1	0	2.753199	0.955474	-1.748272
8	1	0	2.975764	1.239362	-0.027482
9	6	0	-0.530862	-0.172086	-0.961607
10	6	0	1.496085	-1.323022	-1.820096
11	1	0	1.939047	-0.745599	-2.640089
12	6	0	-0.048583	-1.252314	-1.959440
13	1	0	-0.495357	-2.219042	-1.701895
14	1	0	-0.361265	-1.032583	-2.982058
15	6	0	-0.076192	1.186175	-1.542241
16	8	0	-0.507548	1.632503	-2.587320
17	6	0	2.905698	-1.228277	0.402840
18	1	0	3.873495	-1.220134	-0.106714
19	1	0	2.667779	-2.264310	0.653339
20	1	0	3.014873	-0.671909	1.339844
21	6	0	2.005312	-2.773661	-2.001919
22	1	0	1.759828	-3.383361	-1.124856
23	1	0	1.420533	-3.201274	-2.831747
24	6	0	-2.050453	-0.208317	-0.569551
25	8	0	0.445983	3.019491	1.306024
26	8	0	0.074580	-1.708248	0.888240
27	1	0	0.029472	-2.403874	0.220431
28	6	0	4.106786	-4.853276	-0.899819
29	1	0	4.286591	-5.845546	-1.334494
30	1	0	3.085526	-4.841595	-0.514053
31	1	0	4.792851	-4.758513	-0.047607
32	6	0	4.376734	-3.773556	-1.919922
33	6	0	3.466263	-2.888243	-2.359716
34	1	0	3.797333	-2.166994	-3.109817
35	6	0	5.795223	-3.749446	-2.440766
36	1	0	6.057676	-4.705724	-2.912729
37	1	0	6.512037	-3.598897	-1.622102
38	1	0	5.947217	-2.954921	-3.176978
39	6	0	1.375362	3.280286	-1.340525
40	1	0	1.383595	3.161885	-2.430719
41	1	0	0.542450	3.949298	-1.115309
42	6	0	2.689722	3.878026	-0.904426
43	1	0	3.575600	3.336946	-1.239320
44	6	0	2.904270	5.011839	-0.214274
45	6	0	4.312634	5.479266	0.074893

46	1	0	4.489892	6.477801	-0.347159
47	1	0	5.063893	4.798478	-0.336844
48	1	0	4.483109	5.563700	1.156651
49	6	0	1.825505	5.919331	0.322455
50	1	0	1.949023	6.054623	1.404673
51	1	0	0.818588	5.537976	0.154563
52	1	0	1.904047	6.916847	-0.131042
53	6	0	-2.588060	1.111313	0.057249
54	1	0	-2.256663	1.219029	1.091249
55	1	0	-2.220750	1.988457	-0.484149
56	6	0	-4.130887	1.039916	-0.041743
57	1	0	-4.507829	1.855018	-0.665762
58	1	0	-4.617793	1.142241	0.933660
59	6	0	-4.443045	-0.331610	-0.677476
60	1	0	-4.404064	-1.081949	0.123677
61	6	0	-3.182195	-0.648749	-1.580832
62	6	0	-6.515190	-1.606608	-1.182109
63	1	0	-7.499646	-1.729267	-1.626483
64	1	0	-6.125660	-2.452414	-0.621651
65	6	0	-5.820986	-0.464251	-1.310301
66	6	0	-6.434646	0.714500	-2.036542
67	1	0	-7.357518	0.417315	-2.542702
68	1	0	-5.761809	1.148933	-2.781574
69	1	0	-6.686709	1.517892	-1.333193
70	6	0	0.065794	0.573877	2.656505
71	6	0	-0.149780	-0.605449	3.536641
72	6	0	0.774017	-1.655221	3.637498
73	1	0	1.655023	-1.658540	3.008898
74	6	0	-1.273430	-0.601979	4.380386
75	1	0	-1.974675	0.224220	4.328714
76	6	0	-1.491053	-1.650050	5.274504
77	1	0	-2.373800	-1.643718	5.907173
78	6	0	-0.568664	-2.696188	5.364355
79	1	0	-0.729760	-3.506895	6.069196
80	6	0	0.568054	-2.688997	4.551078
81	1	0	1.297825	-3.489845	4.628198
82	8	0	-0.107310	1.709645	3.335656
83	1	0	0.044920	2.474532	2.686960
84	6	0	-3.167174	-2.150989	-1.915438
85	1	0	-4.131742	-2.446132	-2.341166
86	1	0	-2.999802	-2.763419	-1.020448
87	1	0	-2.402339	-2.403393	-2.653929
88	6	0	-3.205926	0.150055	-2.896348
89	1	0	-2.291334	-0.004415	-3.471590

90	1	0	-3.292903	1.227972	-2.736355
91	1	0	-4.048742	-0.176741	-3.514549
92	1	0	-2.090440	-0.968749	0.220459

Conformer4b-2

Center Number	Atomic Number	Atomic Type	Coordinates (Angstroms)		
			X	Y	Z
1	6	0	1.400787	-1.676224	-1.061198
2	6	0	0.826091	-1.691111	0.268257
3	6	0	-0.511403	-0.974424	0.320084
4	6	0	-1.549956	-1.606171	-0.697161
5	6	0	0.542946	-0.993647	-2.122801
6	6	0	-0.792728	-1.821616	-2.045289
7	1	0	-1.424173	-1.549343	-2.896894
8	1	0	-0.527539	-2.877603	-2.168988
9	6	0	-0.436512	0.512017	-0.231282
10	6	0	-2.630869	-0.463850	-0.877139
11	1	0	-2.832390	-0.354607	-1.948294
12	6	0	-1.945687	0.835948	-0.366821
13	1	0	-2.344635	1.114557	0.613923
14	1	0	-2.115854	1.686241	-1.028747
15	6	0	0.116296	0.412539	-1.670831
16	8	0	0.086922	1.348279	-2.447667
17	6	0	-2.095661	-2.953714	-0.209788
18	1	0	-2.750266	-3.402864	-0.965572
19	1	0	-2.657910	-2.871357	0.722486
20	1	0	-1.268263	-3.648625	-0.032855
21	6	0	-4.011331	-0.707018	-0.218141
22	1	0	-4.404203	-1.672819	-0.544156
23	1	0	-3.895132	-0.784897	0.875512
24	6	0	0.394591	1.462052	0.697796
25	8	0	2.457526	-2.267852	-1.376675
26	8	0	-1.007707	-1.009422	1.648277
27	1	0	-1.898898	-0.638977	1.668313
28	6	0	-7.021620	1.535062	-1.391952
29	1	0	-6.581873	2.425085	-0.932949
30	1	0	-8.019216	1.384313	-0.958055
31	1	0	-7.173381	1.740947	-2.459920
32	6	0	-6.156426	0.311537	-1.194442
33	6	0	-4.998261	0.393379	-0.515093
34	1	0	-4.726213	1.374963	-0.125868
35	6	0	-6.716660	-0.947980	-1.811027
36	1	0	-6.081988	-1.824528	-1.668719
37	1	0	-6.865842	-0.812138	-2.890256
38	1	0	-7.703844	-1.175592	-1.387532

39	6	0	1.151958	-1.031939	-3.538825
40	1	0	1.335606	-2.079367	-3.791597
41	1	0	0.372854	-0.668819	-4.221725
42	6	0	2.389730	-0.194745	-3.753148
43	1	0	2.230587	0.875422	-3.640433
44	6	0	3.617715	-0.606857	-4.112025
45	6	0	4.029556	-2.041724	-4.327101
46	1	0	4.869437	-2.296913	-3.668018
47	1	0	4.379987	-2.191358	-5.357497
48	1	0	3.230339	-2.755494	-4.126231
49	6	0	4.725747	0.397373	-4.334420
50	1	0	4.384353	1.424329	-4.174653
51	1	0	5.123911	0.325217	-5.355765
52	1	0	5.569081	0.206651	-3.656713
53	6	0	1.935108	1.352018	0.509127
54	1	0	2.325973	0.443508	0.970858
55	1	0	2.202064	1.299517	-0.551354
56	6	0	2.541732	2.625542	1.145527
57	1	0	3.064218	3.214557	0.386664
58	1	0	3.277865	2.394241	1.922446
59	6	0	1.345424	3.409296	1.726582
60	1	0	1.106963	2.968200	2.704147
61	6	0	0.122227	3.015188	0.802413
62	6	0	1.076822	5.477949	3.077011
63	1	0	1.233745	6.533443	3.284075
64	1	0	0.489617	4.921926	3.803155
65	6	0	1.590935	4.889517	1.984925
66	6	0	2.463772	5.685268	1.037613
67	1	0	2.434612	6.749498	1.288245
68	1	0	2.163521	5.572364	-0.008269
69	1	0	3.508974	5.358153	1.102344
70	6	0	1.482131	-2.416919	1.255862
71	6	0	1.131696	-2.604433	2.690904
72	6	0	1.064508	-3.914826	3.190752
73	1	0	1.204440	-4.751297	2.513573
74	6	0	0.993831	-1.527655	3.577325
75	1	0	1.064622	-0.513001	3.205250
76	6	0	0.771867	-1.757979	4.935119
77	1	0	0.677297	-0.915342	5.613924
78	6	0	0.672230	-3.064622	5.421362
79	1	0	0.491979	-3.240836	6.477956
80	6	0	0.817067	-4.143266	4.544652
81	1	0	0.749445	-5.161853	4.915520
82	8	0	2.596712	-3.084156	0.953548

83	1	0	2.787478	-2.917127	-0.029947
84	6	0	-1.190949	3.366523	1.523452
85	1	0	-1.172372	4.414675	1.839120
86	1	0	-1.336276	2.752005	2.420710
87	1	0	-2.062696	3.242720	0.876652
88	6	0	0.160410	3.762771	-0.542653
89	1	0	1.097666	3.612673	-1.085469
90	1	0	0.028404	4.836736	-0.373758
91	1	0	-0.638843	3.427356	-1.205567
92	1	0	0.166455	1.091100	1.705302

3Experimental and calculated ECD spectra

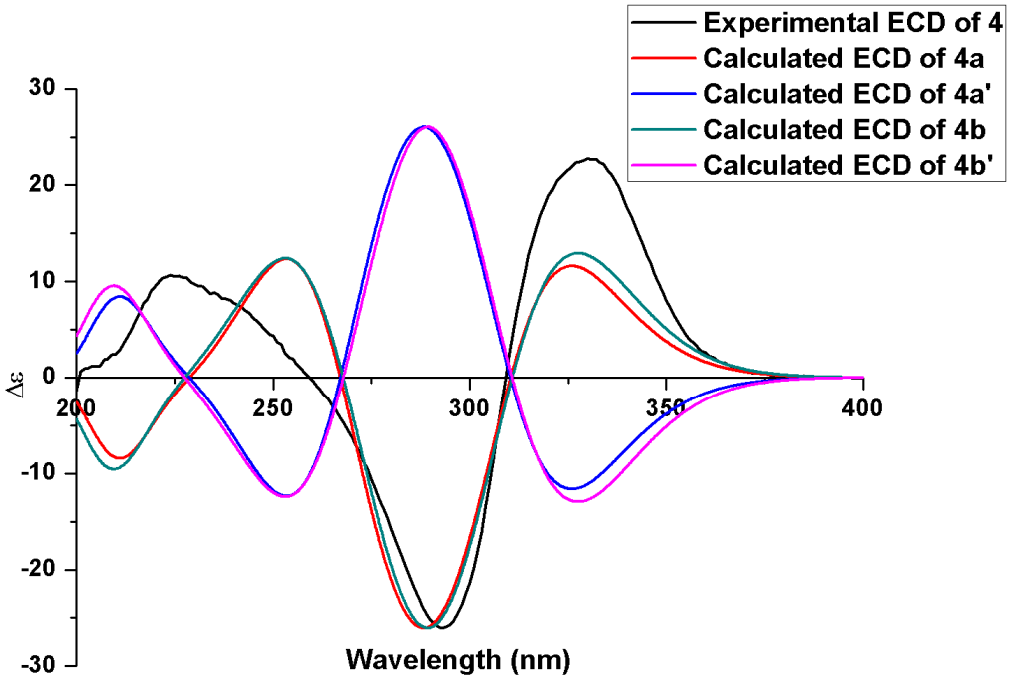
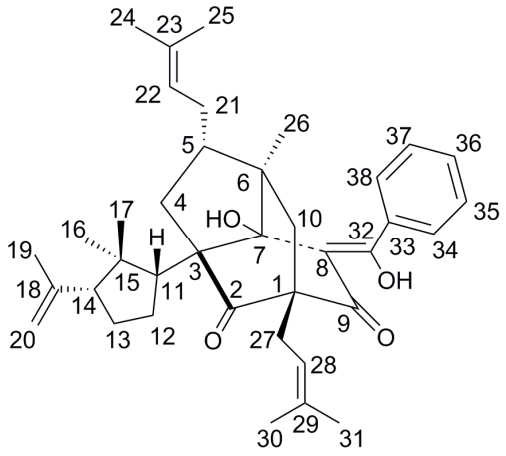


Figure S4 Calculated ECD spectra were compared with the experimental.

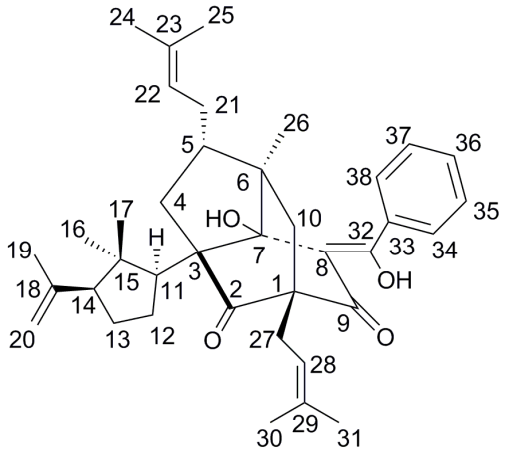
4Experimental and Computed NMR Chemical Shifts

4.1^{13}C- and ^{1}H-NMR chemical shifts

The TMS-corrected computed ^{13}C- and ^{1}H-NMR chemical shifts of compound **4** were fitted to the experimental values by Ordinary Least Squares (OLS) Linear Regression method in order to remove systematic error that results from the conformational search and random error from experimental conditions (**Table S**9 and **S10**).



4a



4b

Table S9 Experimental and computed ^{13}C-NMR chemical shifts.

Position	Experimental	Calculated	
		4a	4b
1	63.4	65.0	65.5
2	211.5	210.9	211.4
3	62.7	66.5	67.0
4	40.0	36.5	36.9
5	48.5	47.9	48.1
6	47.1	48.0	48.0
7	84.7	86.4	86.6
8	109.2	106.4	106.9
9	199.8	195.8	195.3
10	46.9	48.7	49.0
11	37.9	46.6	50.5
12	32.4	26.3	25.1
13	28.4	25.3	24.8
14	48.2	59.7	56.7
15	40.6	48.1	48.9
16	25.1	24.4	25.5
17	24.3	23.0	17.4

18	146.2	152.0	148.3
19	23.9	19.0	20.6
20	109.3	110.3	112.7
21	33.4	34.0	34.4
22	123.4	122.6	123.1
23	132.4	133.9	133.6
24	18.2	20.8	20.2
25	26.0	19.4	20.6
26	19.5	17.3	16.8
27	25.2	27.0	26.5
28	119.5	118.7	118.7
29	134.2	136.1	136.5
30	18.1	21.1	20.5
31	26.2	20.1	21.4
32	175.4	174.2	174.4
33	135.1	133.9	134.1
34	128.0	127.6	127.5
35	128.6	123.3	123.3
36	130.7	127.6	127.4
37	128.6	123.3	123.3
38	128.0	127.6	127.5

Table S10 Experimental and computed ^{1}H-NMR chemical shifts.

Position	Experimental	Calculated	
		4a	4b
4a	1.94	2.35	2.33
4b	1.39	1.50	1.56
5	1.56	1.55	1.54
10	1.64	1.54	1.51
11	1.70	2.21	2.12
12	1.72	1.33	1.36
13	2.07	1.56	1.62
14	2.39	2.19	2.17
16	1.02	1.07	1.00
17	0.83	0.93	0.94
19	1.65	1.37	1.69
20	4.83	4.56	4.78
21	2.12	2.08	2.01
22	4.95	5.20	5.14
24	1.55	1.72	1.70
25	1.65	1.70	1.67
26	1.15	1.25	1.02
27	2.47	2.41	2.43

28	5.19	5.36	5.30
30	1.65	1.78	1.78
31	1.72	1.76	1.76
34	7.50	7.62	7.56
35	7.47	7.25	7.29
36	7.50	7.36	7.38
37	7.47	7.25	7.29
38	7.50	7.62	7.56

Comparable high R^2 and low CMAD and CLAD values were seen for both configurations 4a and 4b in ^{13}C-NMR while significantly higher correlation with the experimental values was shown for configuration 4b compared with 4a in ^{1}H-NMR, suggesting that the former is the most likely candidate for compound **4** (**Table S11** and **Figure S5-6**).

Table S11 Statistics of Ordinary Least Squares (OLS) Linear Regression of experimental and computed ^{13}C- and ^{1}H-NMR chemical shifts.

Type	configuration	CMAD[a]	CLAD[b]	R^2	*RMSE*	*F*	*p* value
C	4a	3.1	11.5	0.9948	4.2	6495.61	< 0.01
	4b	3.2	12.6	0.9944	4.3	6058.55	< 0.01
H	4a	0.18	0.51	0.9878	0.24	1788.44	< 0.01
	4b	0.15	0.45	0.9911	0.21	2448.60	< 0.01

[a] CMAD = corrected mean absolute deviation, computed as $(1/n)\sum_{i}^{n}|\delta_{\text{calc}}-\delta_{\text{exp}}|$, where δ_{calc} and δ_{exp} refer to the calculated and experimental chemical shifts. [b] CLAD = corrected largest absolute deviation, computed as $\max(|\delta_{\text{calc}}-\delta_{\text{exp}}|)$.

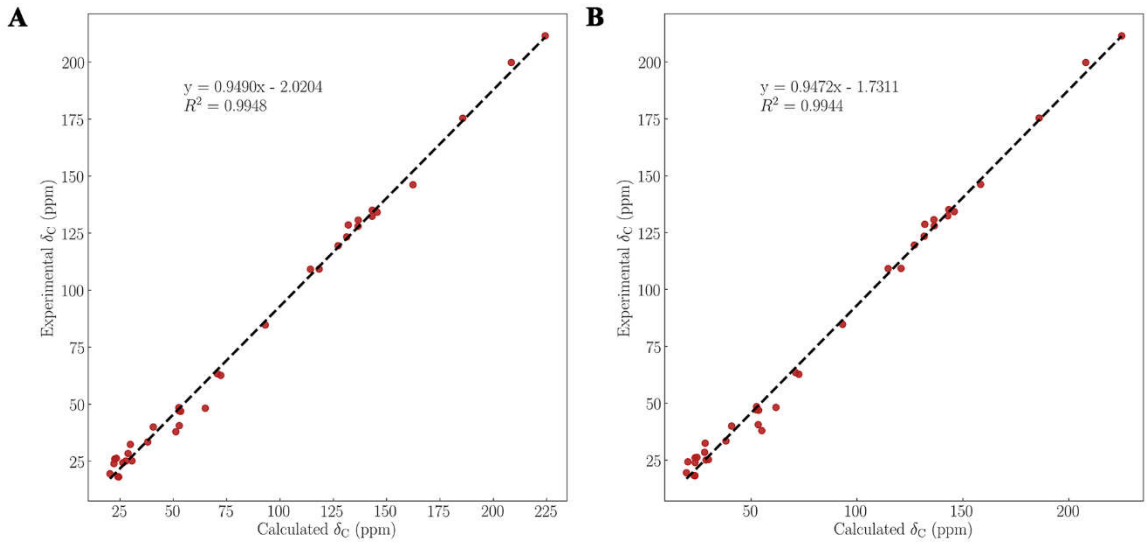


Figure S5 Linear regression fitting of computed ^{13}C-NMR chemical shifts of configurations 4a (A) and 4b (B) of compound **4** with the experimental values.

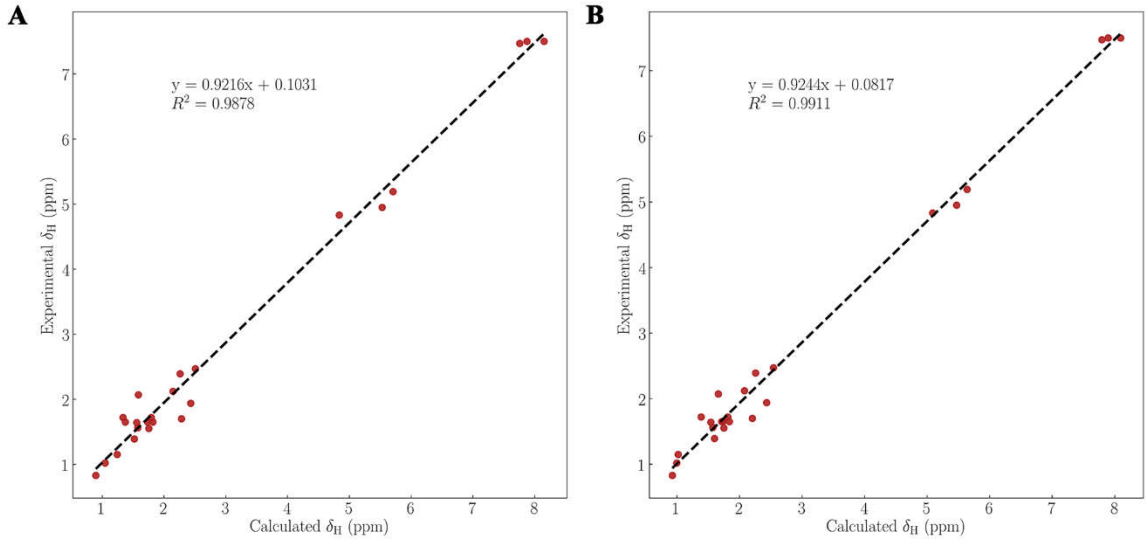


Figure S6 Linear regression fitting of computed ^{1}H-NMR chemical shifts of configurations 4a (A) and 4b (B) of compound **4** with the experimental values.