Electronic Supplementary Material (ESI) for Organic & Biomolecular Chemistry.

A molecular receptor for zwitterionic phenylalanine

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Figure S1. ^{1}H NMR spectrum of compound 3 (200 MHz, $CDCl_3$).

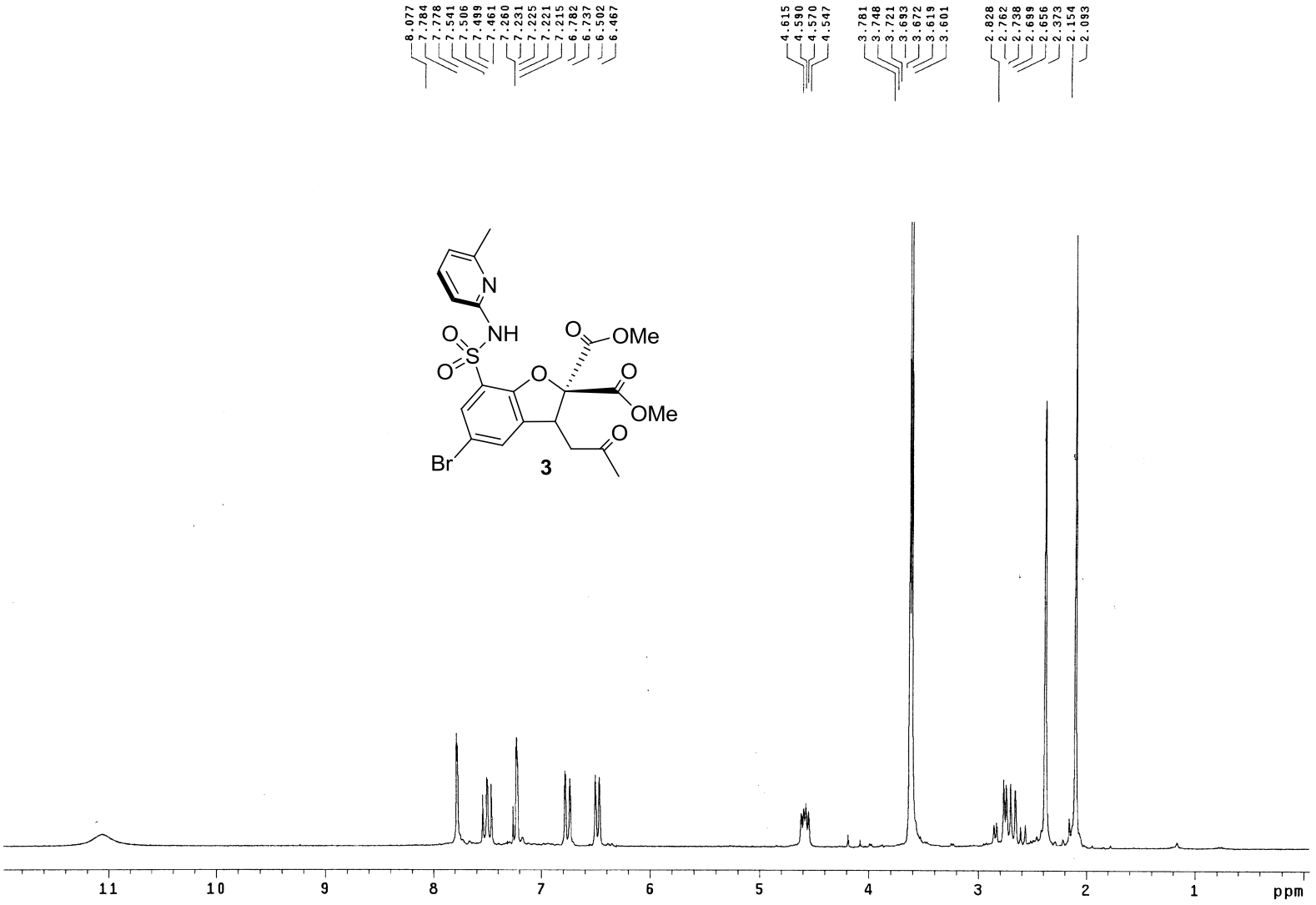


Figure S2. ^{13}C NMR spectrum of compound 3 (100 MHz, $CDCl_3$).

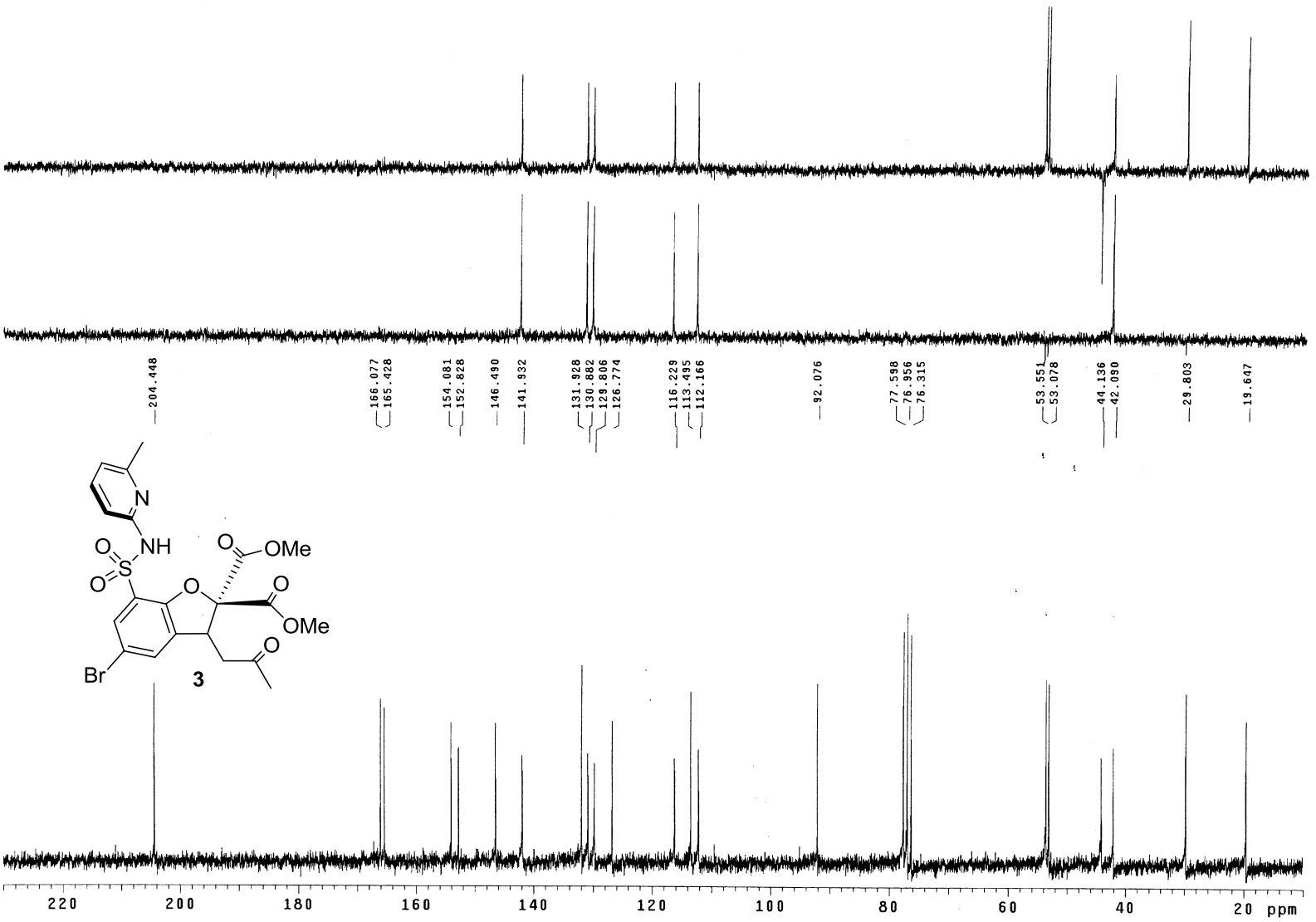


Figure S3. IR spectrum of compound 3.

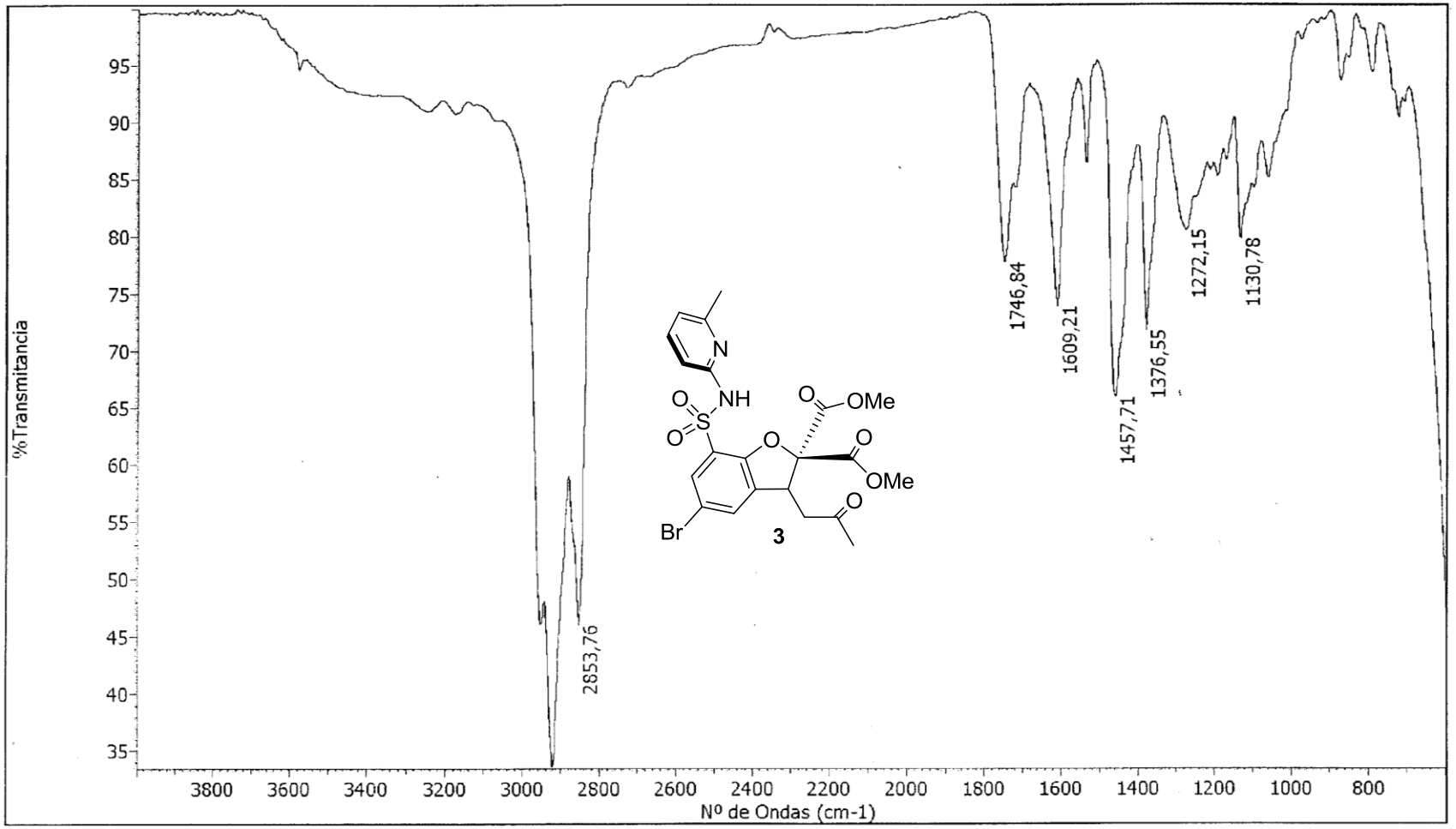


Figure S4. HRMS spectrum of compound 3 (ESI-QTOF).

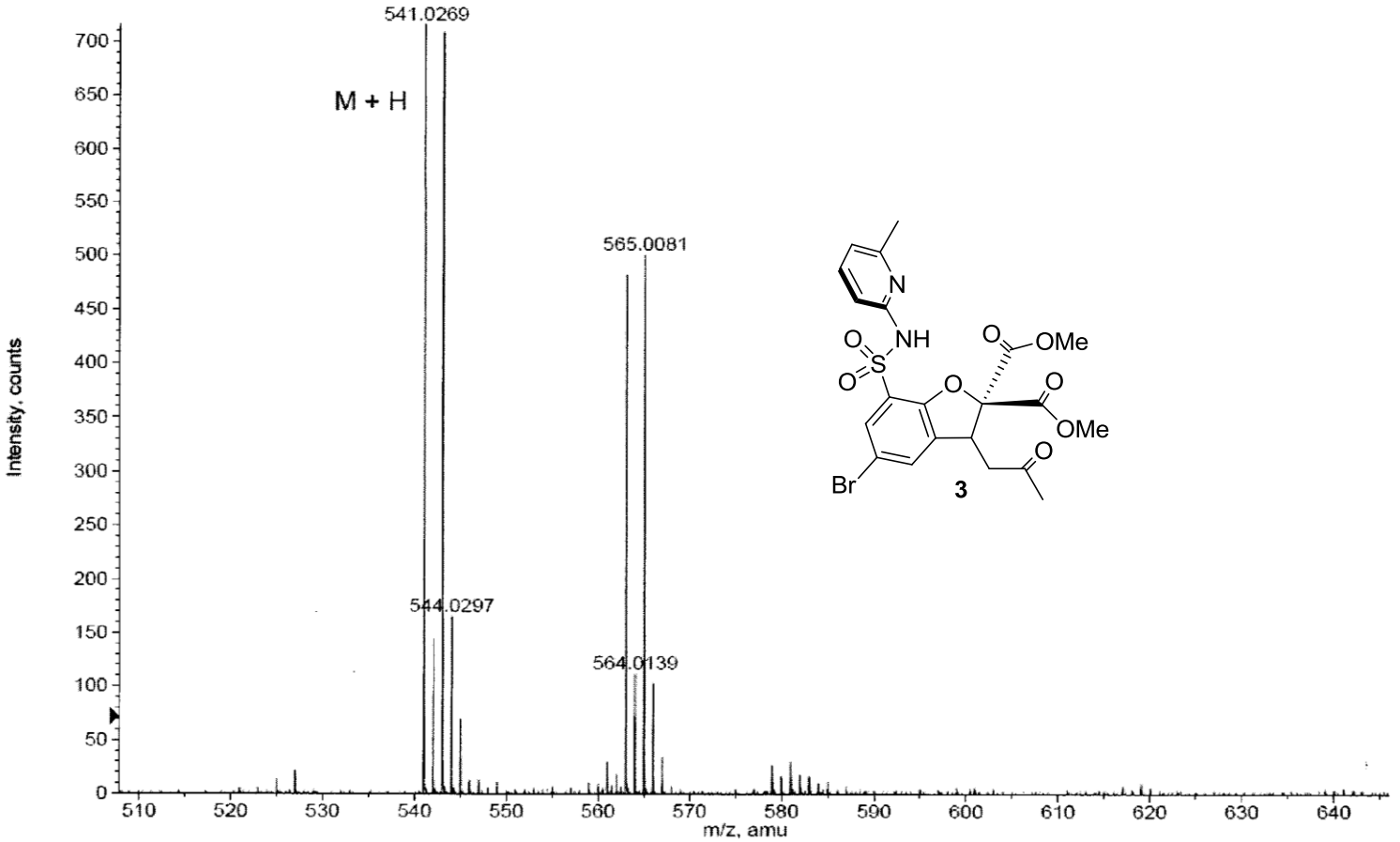


Figure S5. ^{1}H NMR spectrum of receptor 1 (400 MHz, $CDCl_3$).

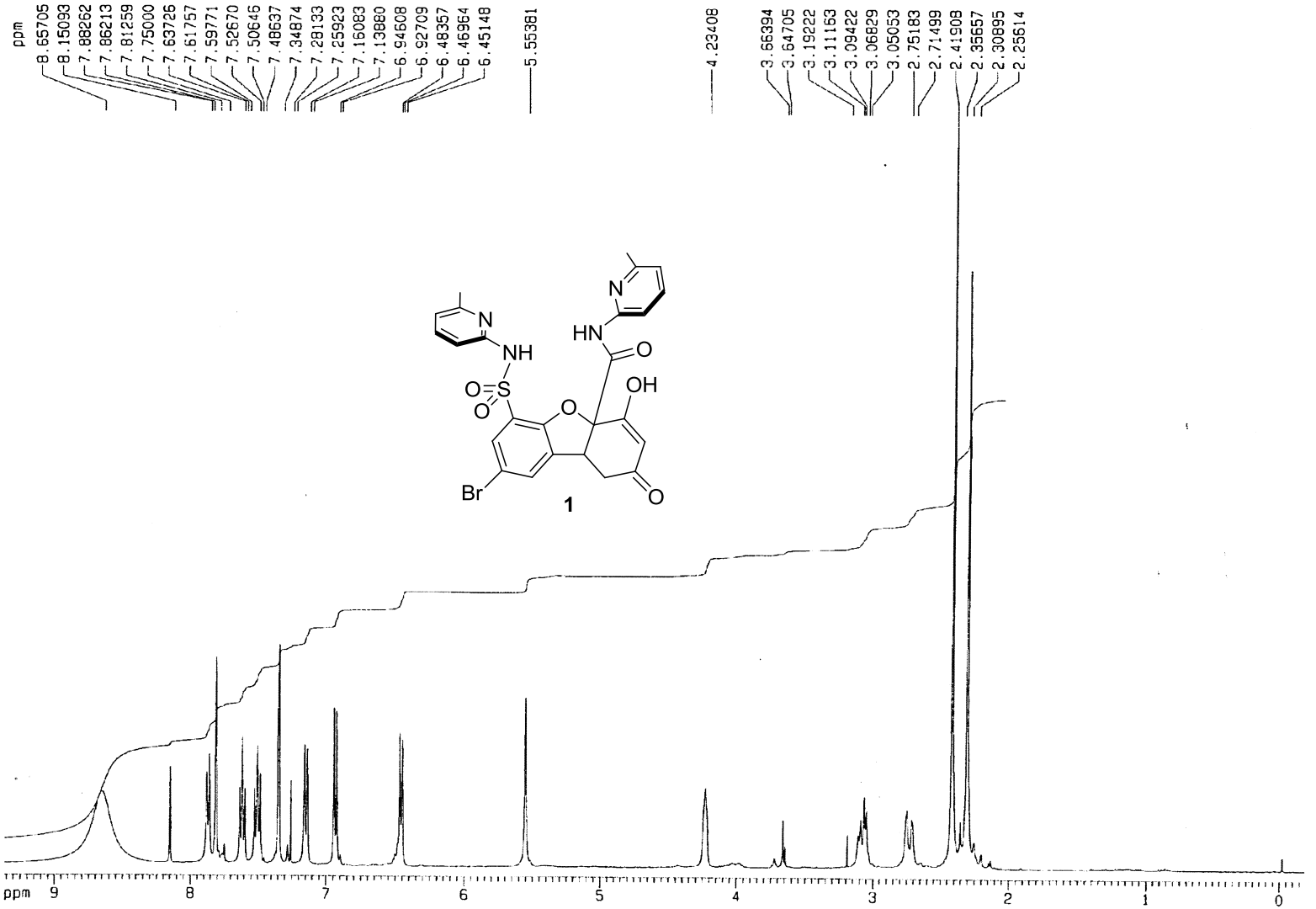


Figure S6. ^{13}C NMR spectrum of receptor 1 (100 MHz, $CDCl_3$).

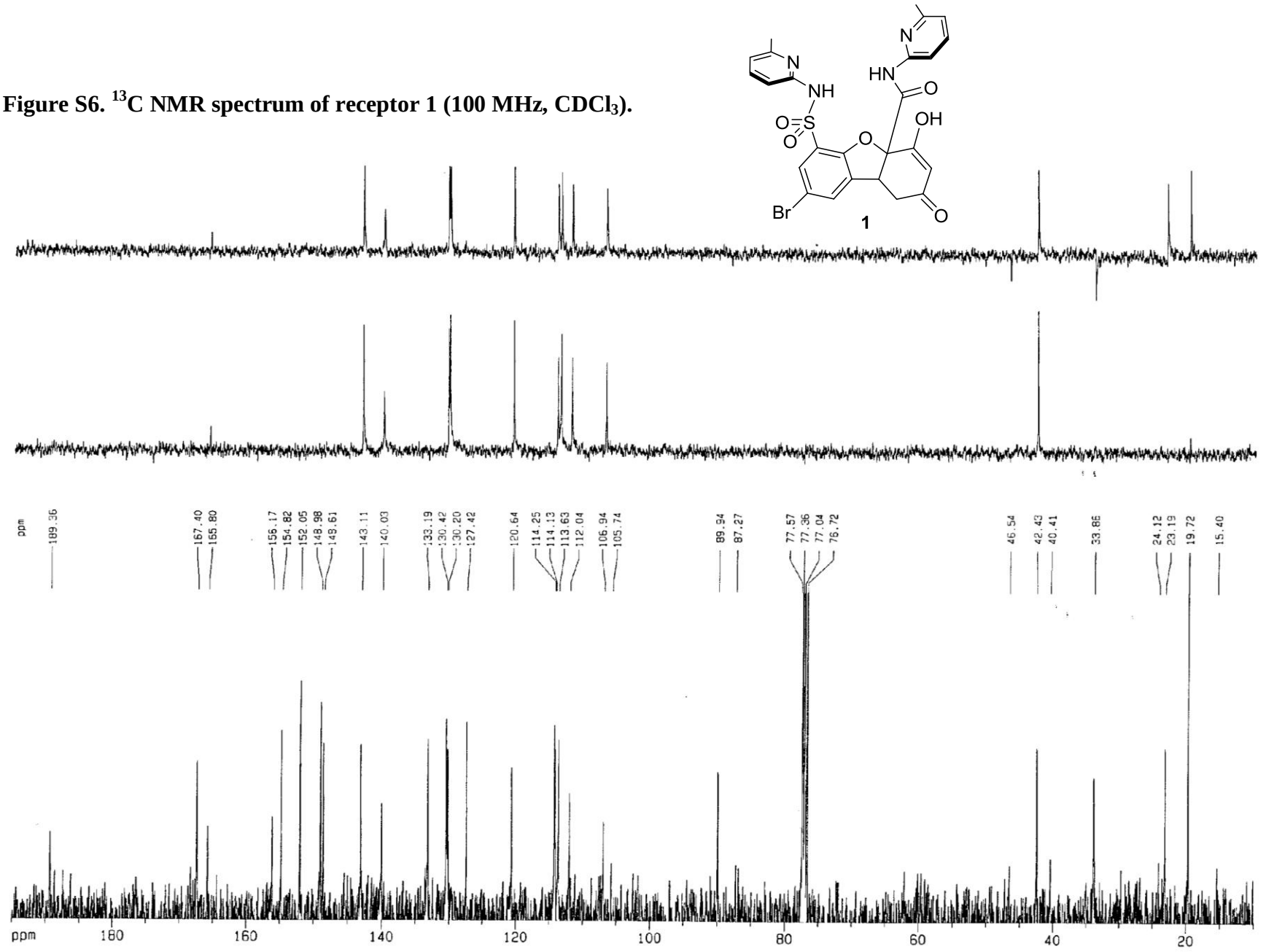


Figure S7. COSY spectrum of receptor 1 ($CDCl_3$).

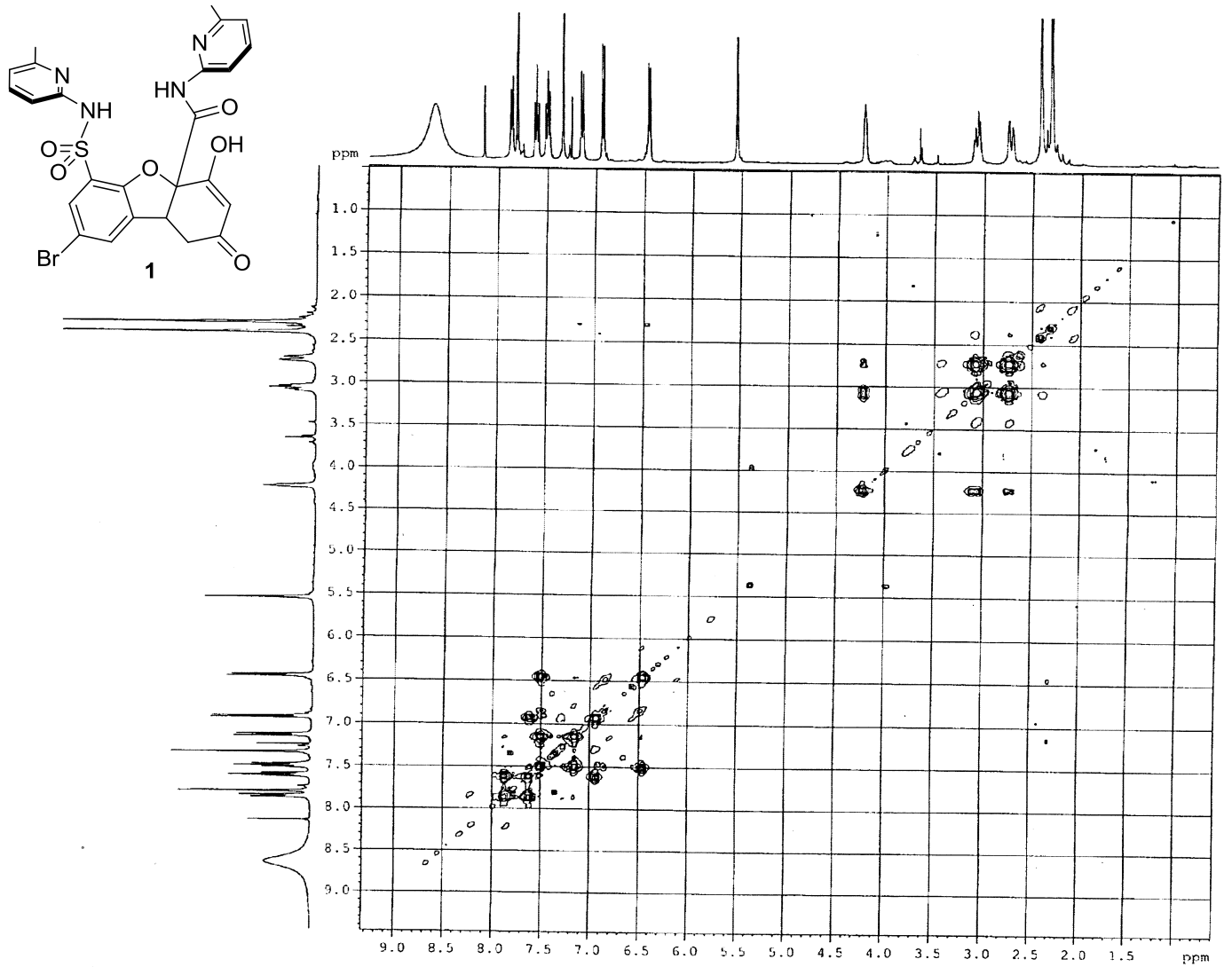


Figure S8. ROESY spectrum of receptor 1 ($CDCl_3$).

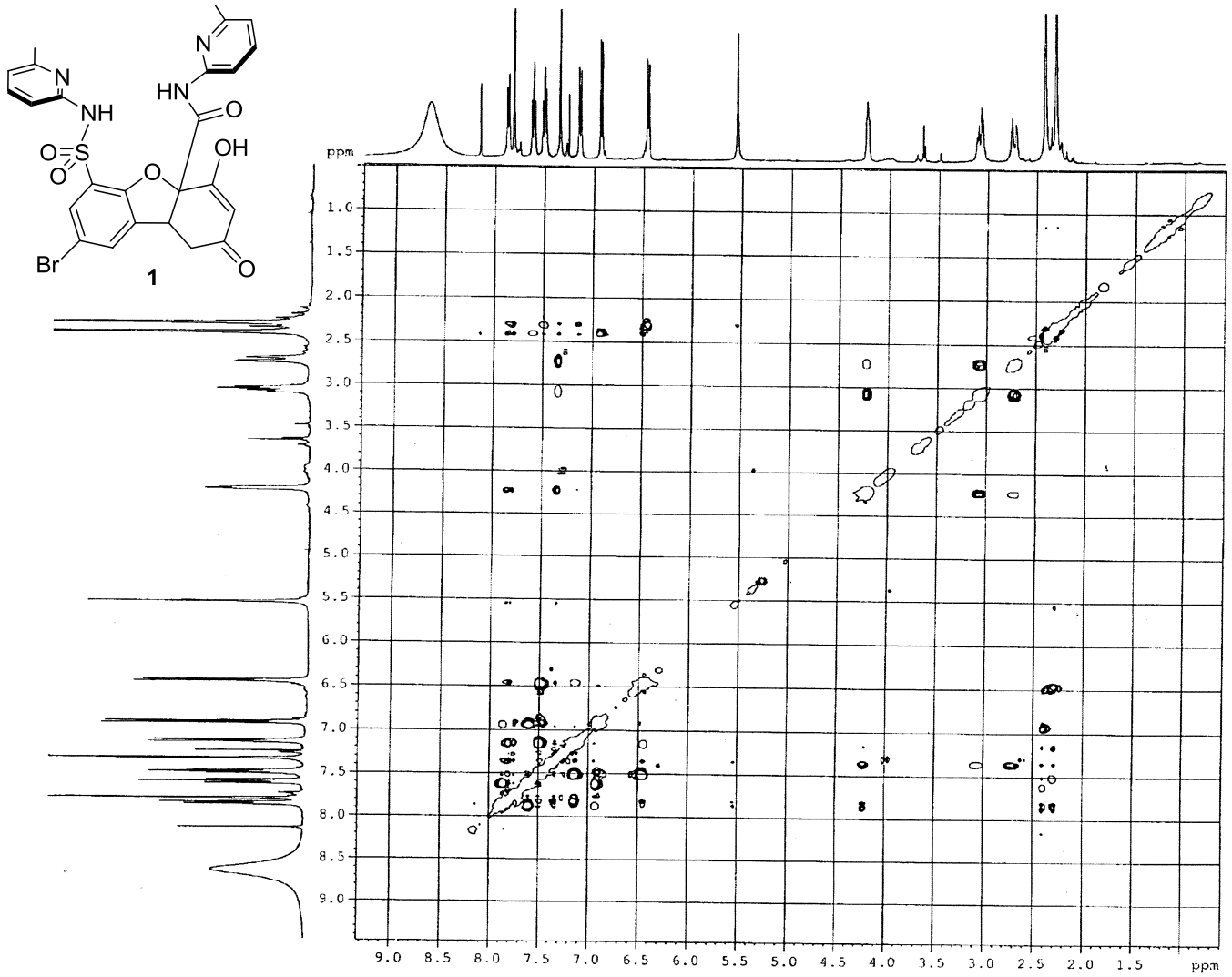


Figure S9. HMQC spectrum of receptor 1 ($CDCl_3$).

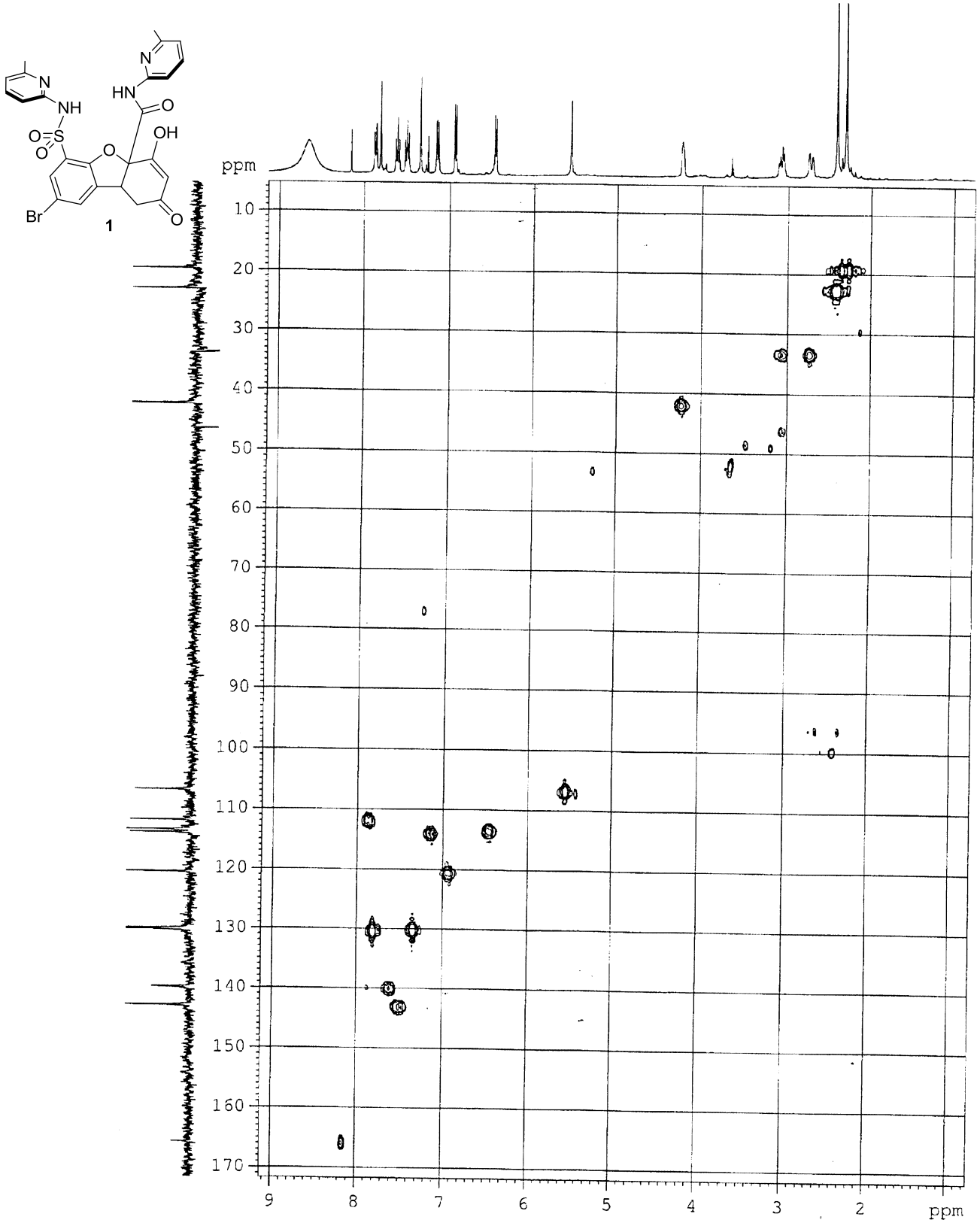


Figure S10. HMBC spectrum of receptor 1 ($CDCl_3$).

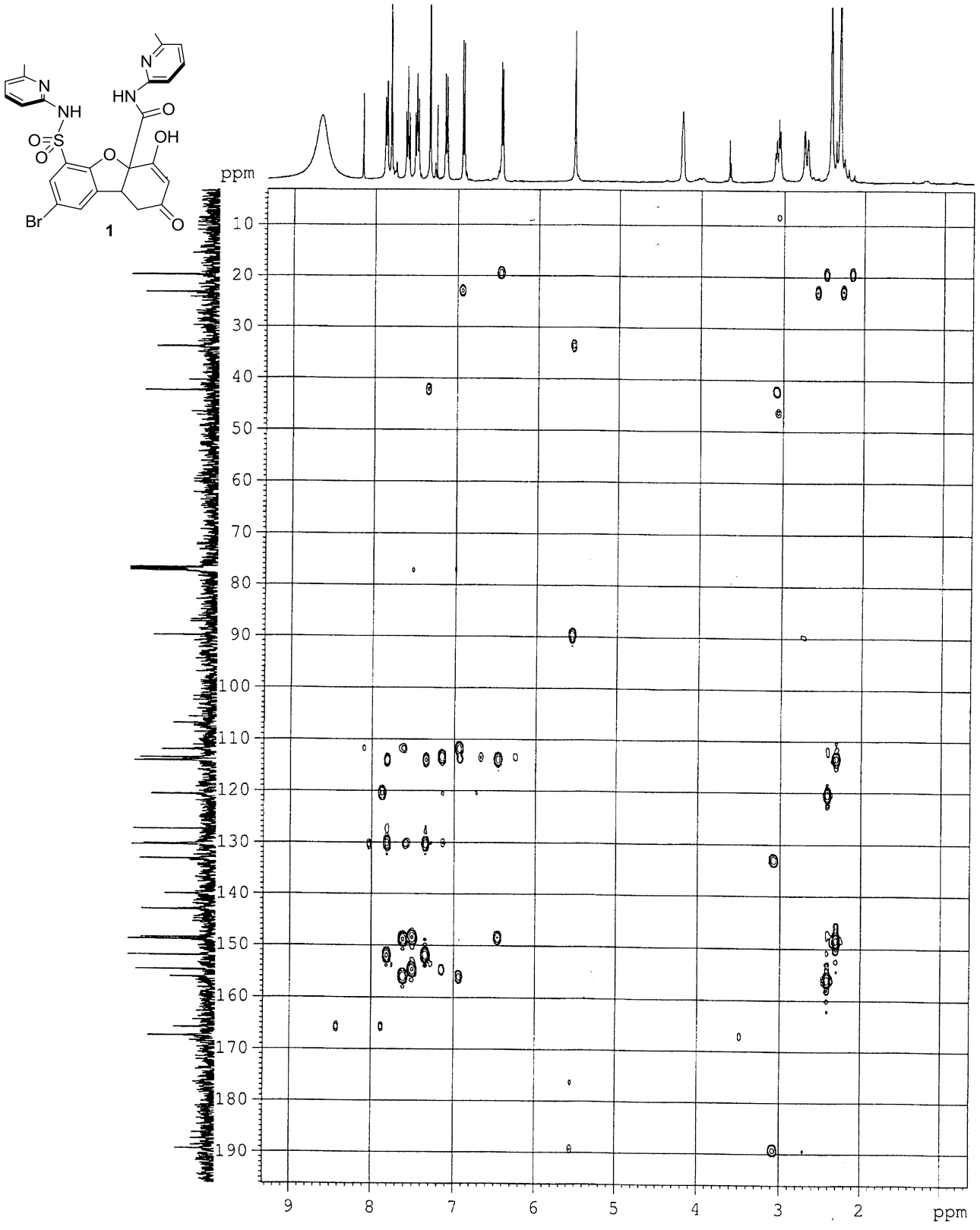


Figure S11. IR spectrum of receptor 1.

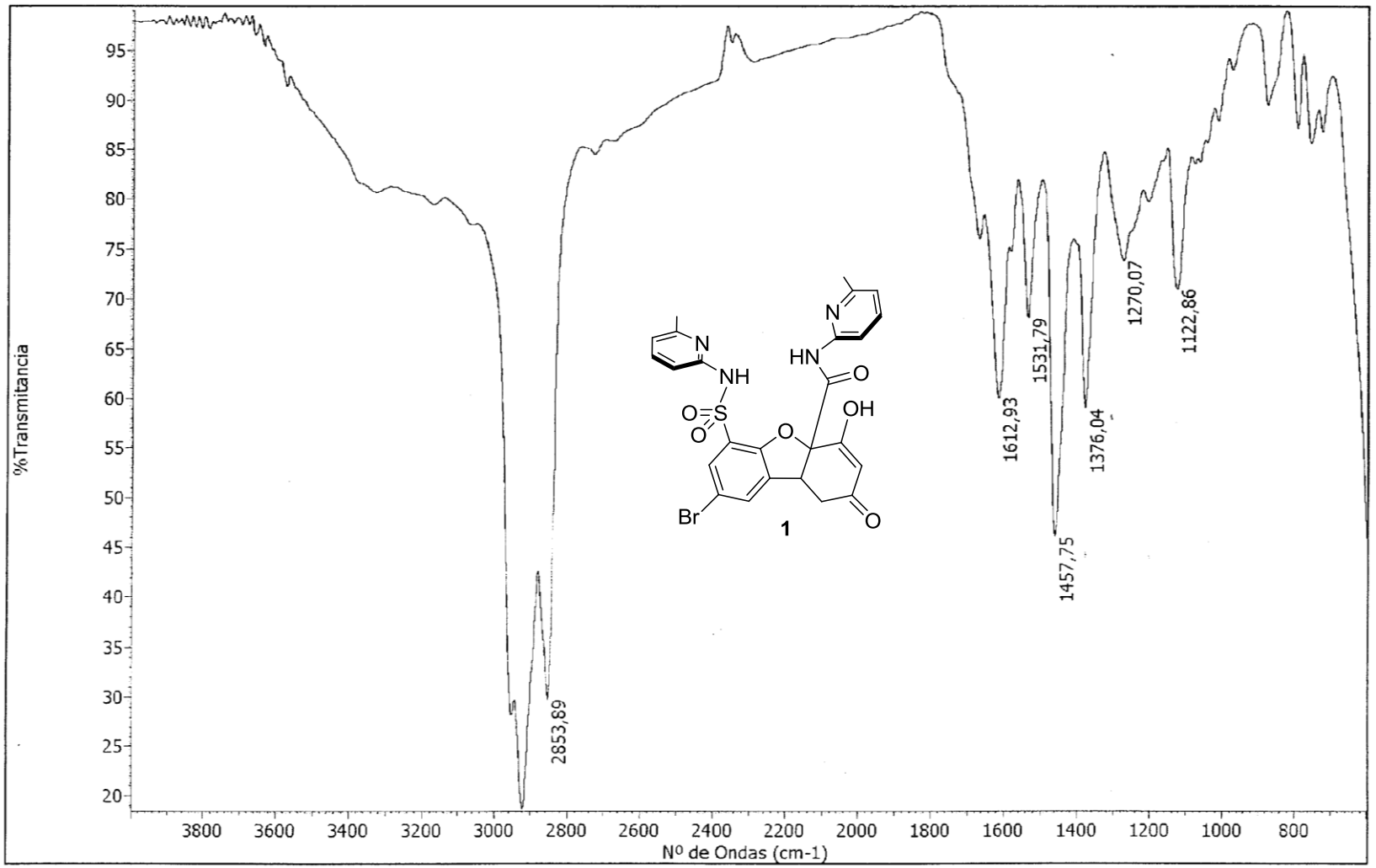


Figure S12. HRMS spectrum of receptor 1 (ESI-QTOF).

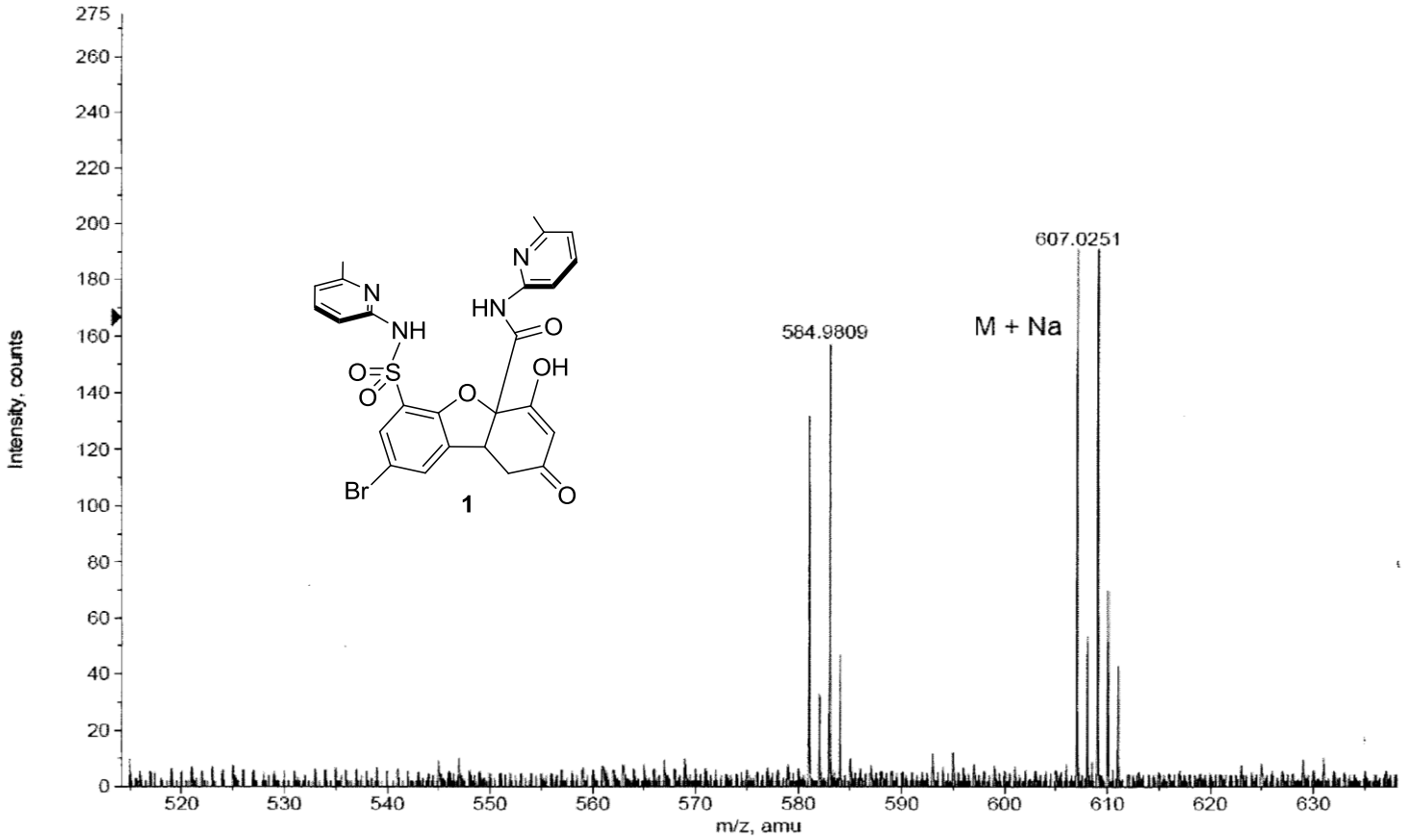


Figure S13. ^{1}H NMR spectrum of receptor 1 with *rac*-phenylalanine (200 MHz, $CDCl_3$).

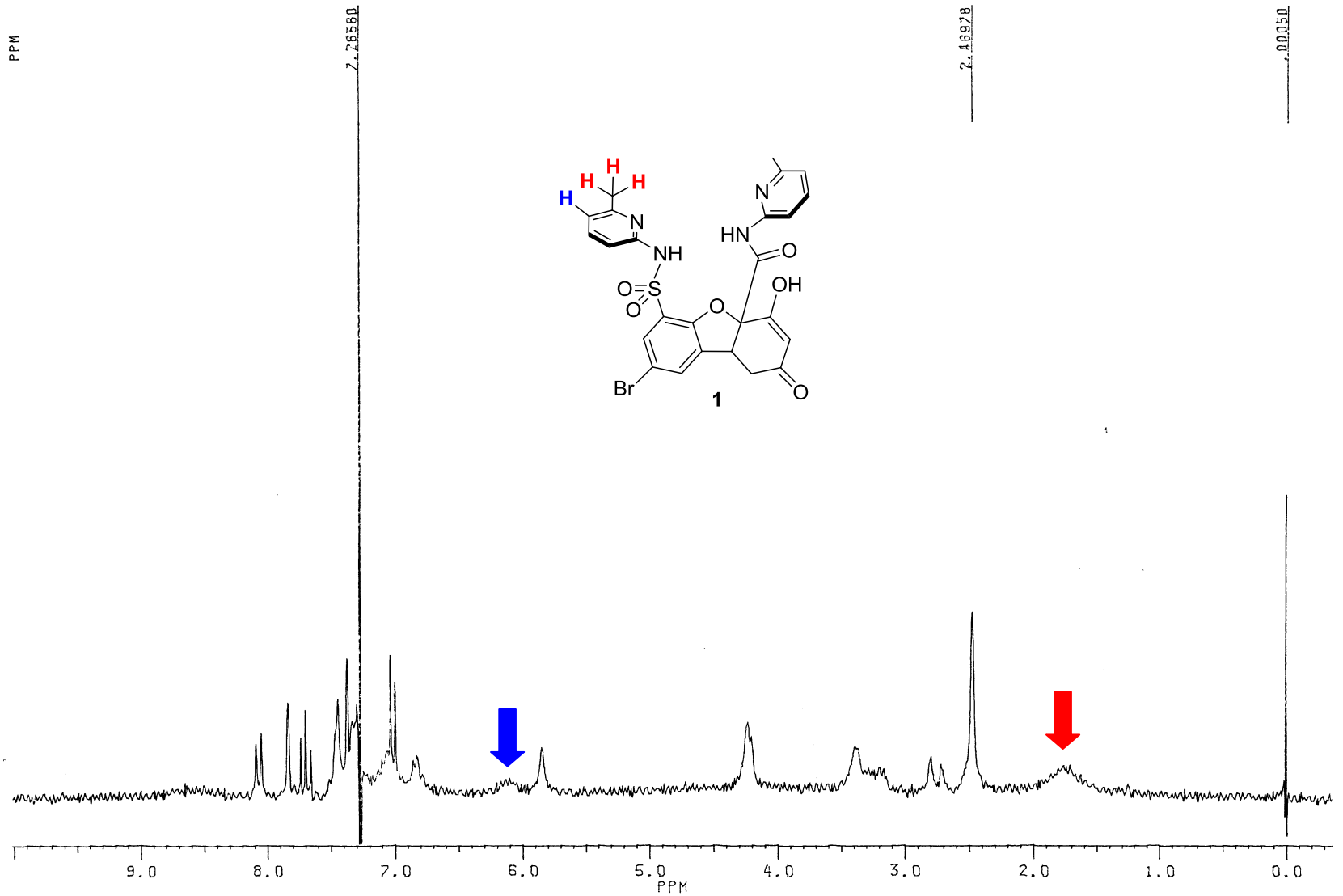


Figure S14. ^{1}H NMR spectrum of receptor 1 with *rac*-phenylalanine (DMSO-d_6).

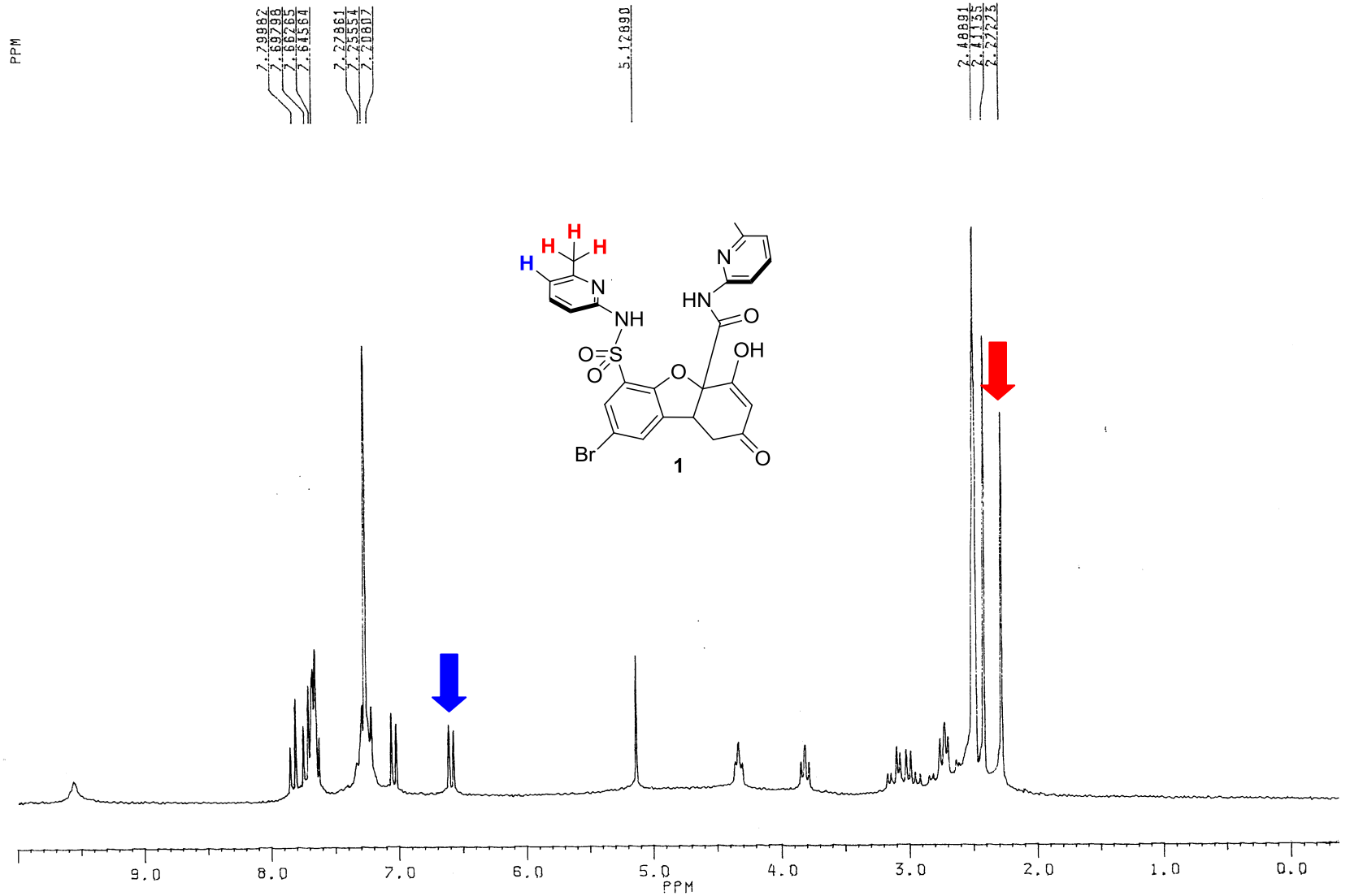


Figure S15. ^{1}H NMR spectrum of receptor 1 and the associates with *L*-phenylalanine (200 MHz, $CDCl_3$).

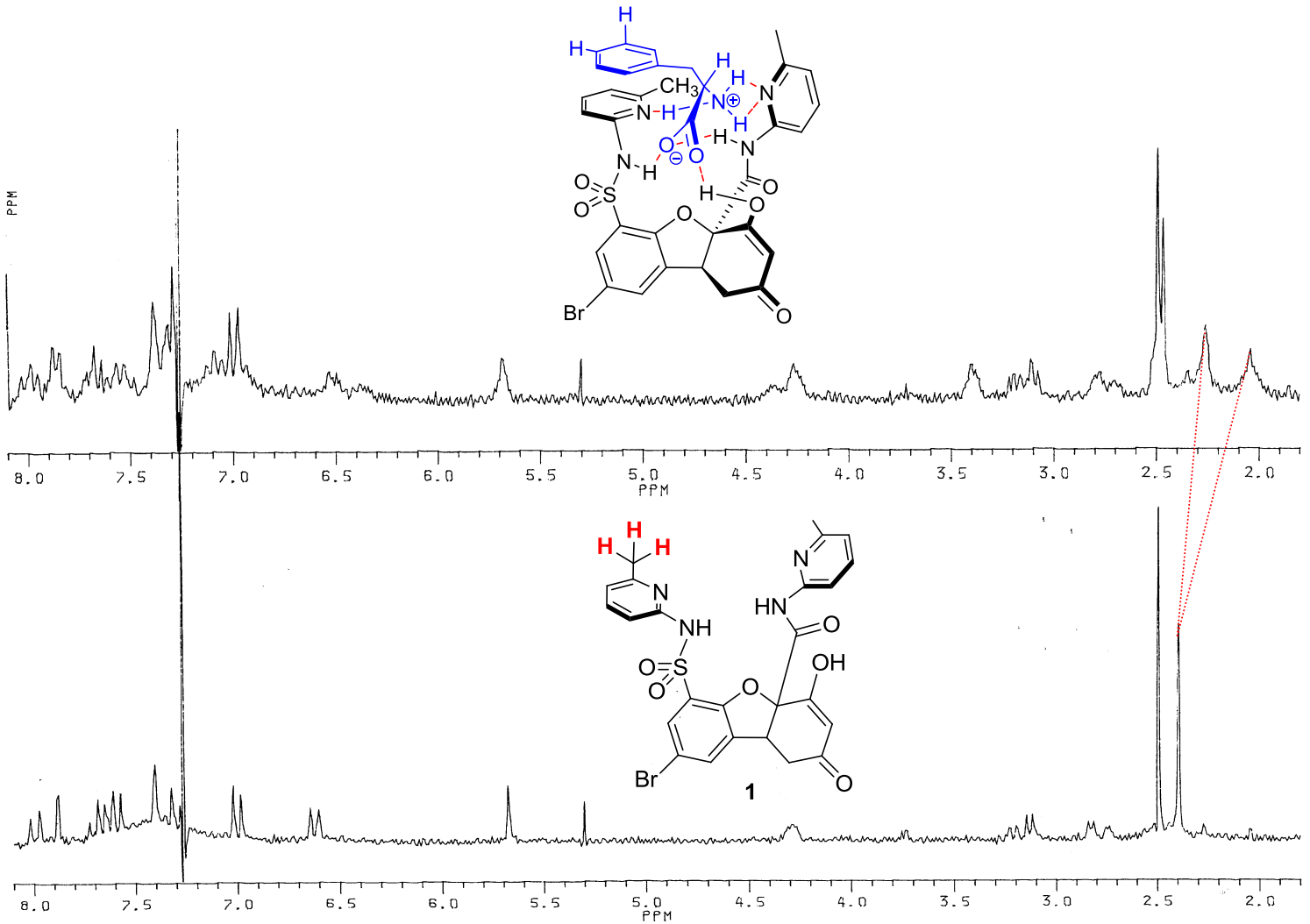
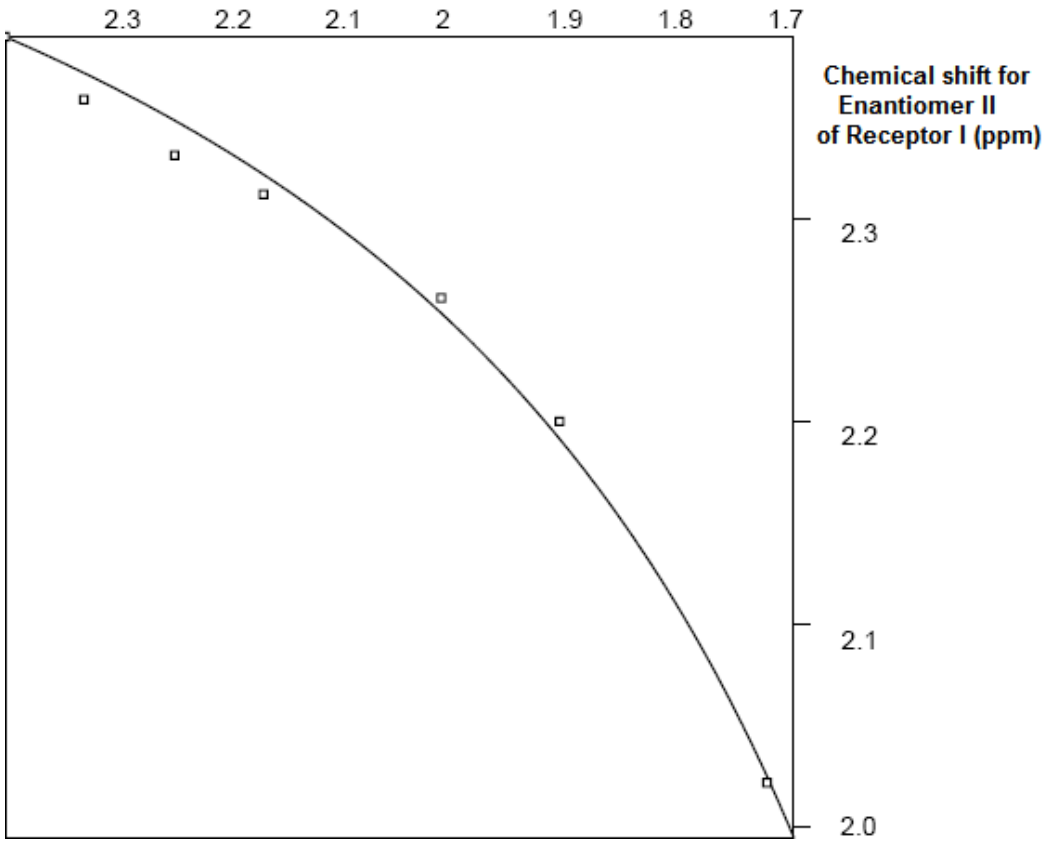


Figure S16. ^{1}H NMR titration of receptor 1 with *L*-phenylalanine ($CDCl_3$, 20°C).

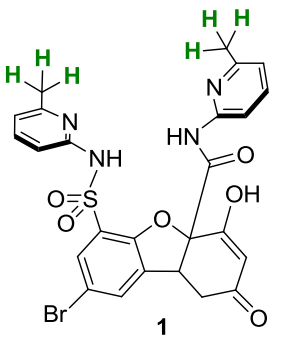
Competitive titration
Constant: 2.3 1/M
Max. shift 1 (ppm): 1.6759
Max. shift 2 (ppm): 1.9951

Host 1: Enantiomer I of Receptor 1
Host 2: Enantiomer II of Receptor 1

Guest: L-Phenylalanine



Shift Enantiomer I	Shift Enantiomer II
2.3896	2.3896
2.3184	2.3586
2.2362	2.3312
2.1559	2.3119
1.9951	2.2608
1.888	2.2001
1.7001	2.0221



1

Figure S17. ^{1}H NMR spectrum of solid residue obtained after preparative TLC of receptor 1 with *L*-phenylalanine impregnated plates (a) and the receptor 1 (b) (DMSO-d_6).

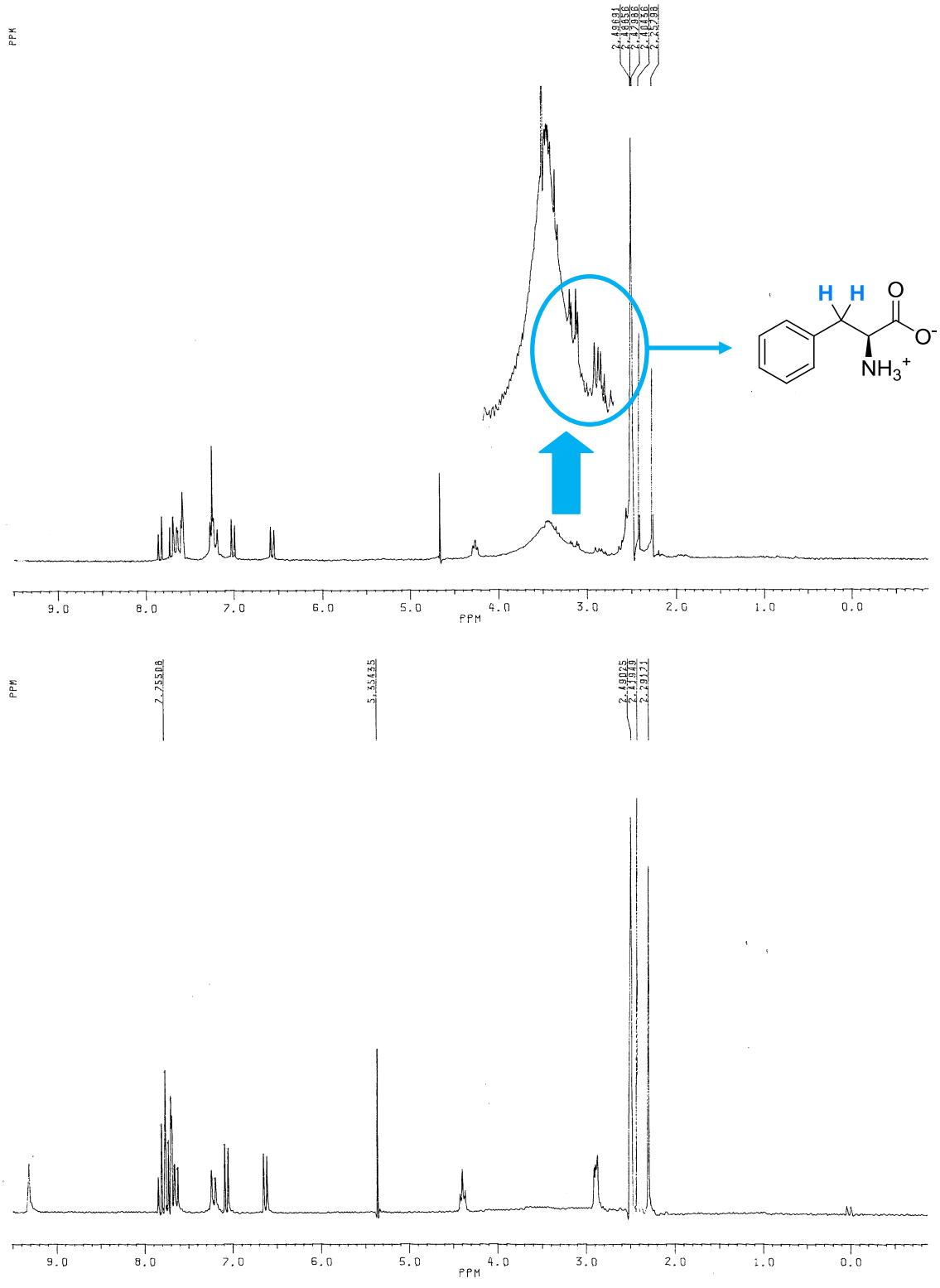


Figure S18. ^{1}H NMR spectrum of weak complex of receptor 1 with *L*-phenylalanine ($CDCl_3$).

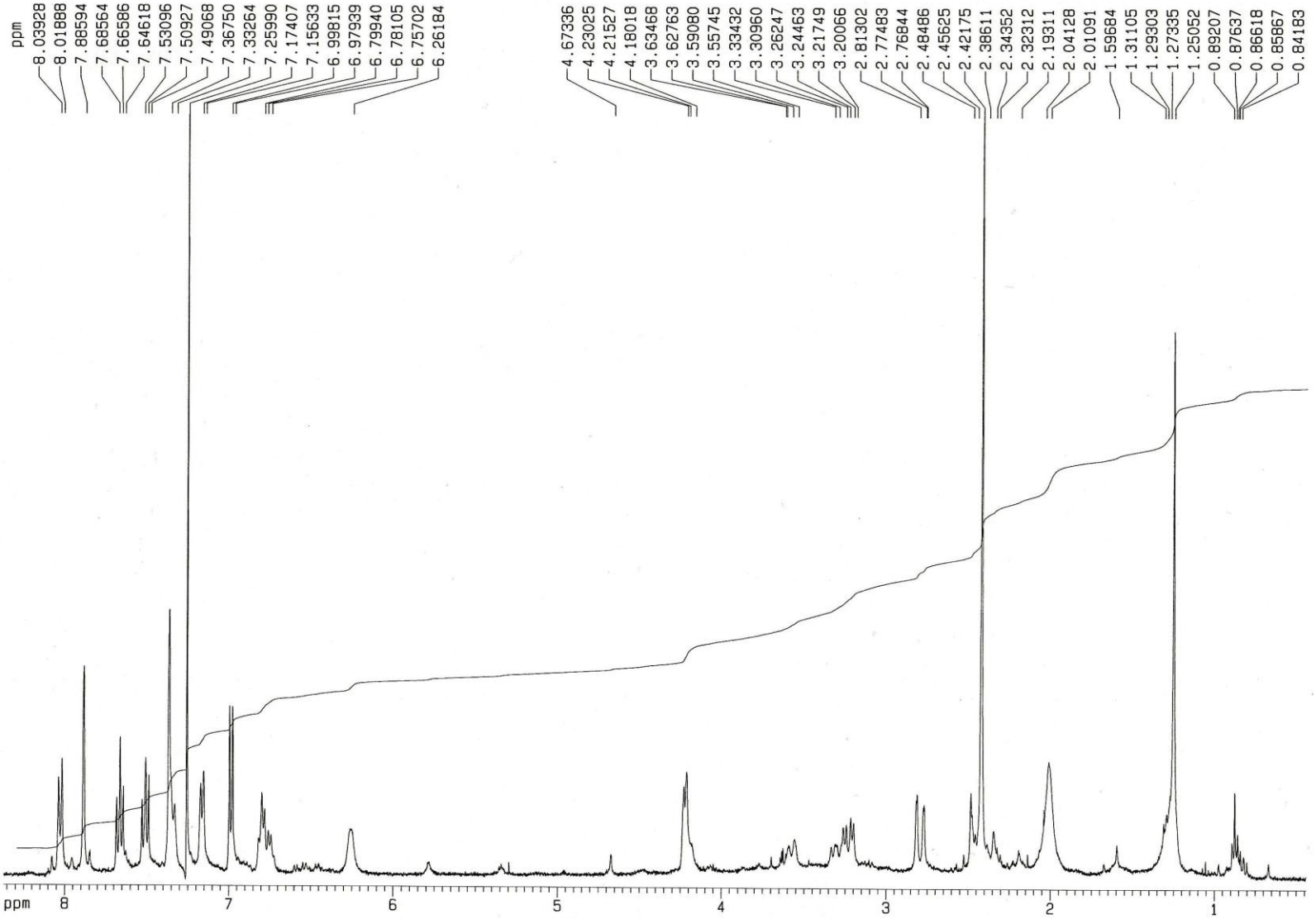


Figure S19. ROESY spectrum of weak complex of receptor 1 with *L*-phenylalanine ($CDCl_3$).

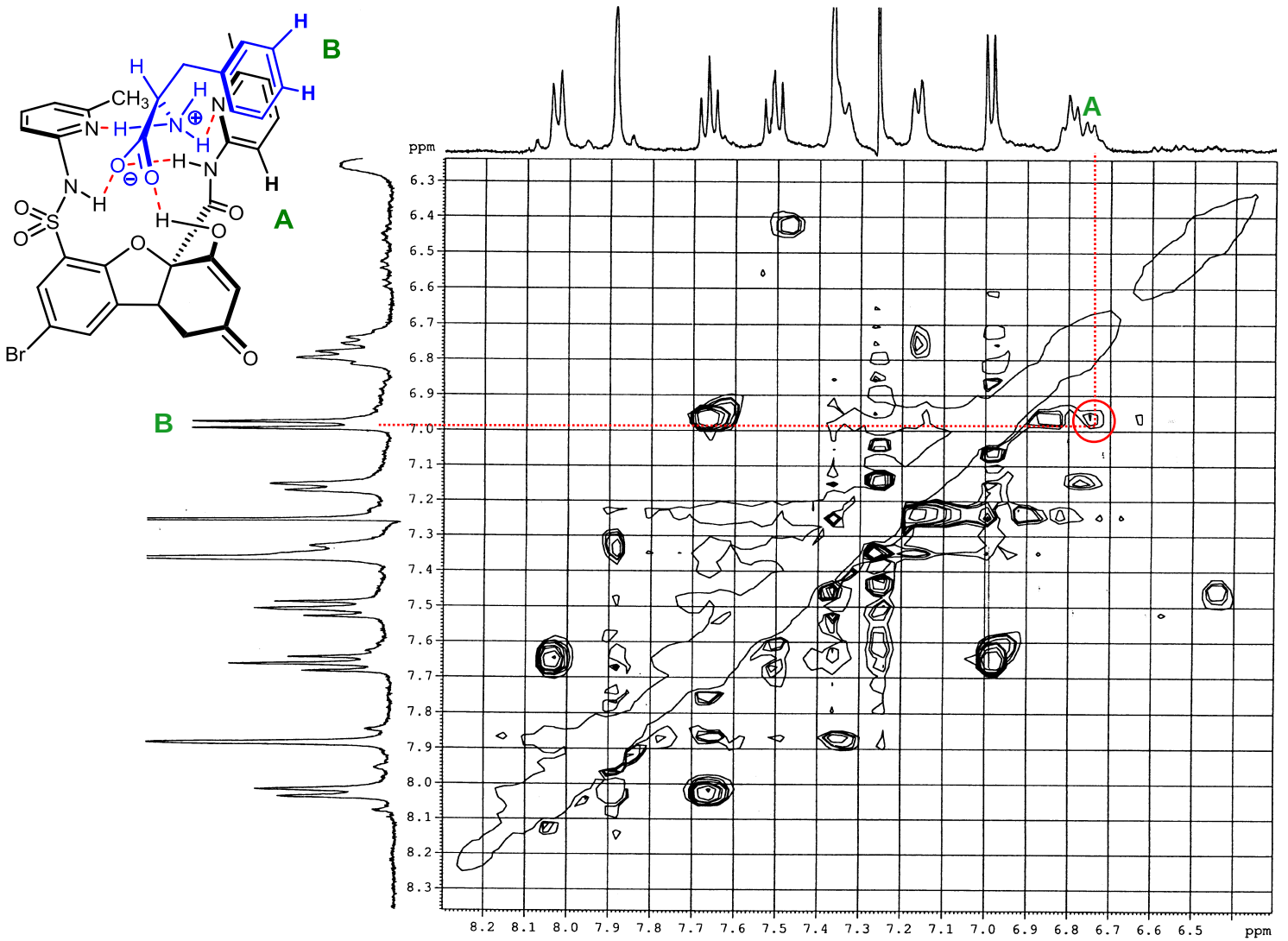


Figure S20. **^{1}H NMR spectrum of strong complex of receptor 1 with *L*-phenylalanine ($CDCl_3$)**.

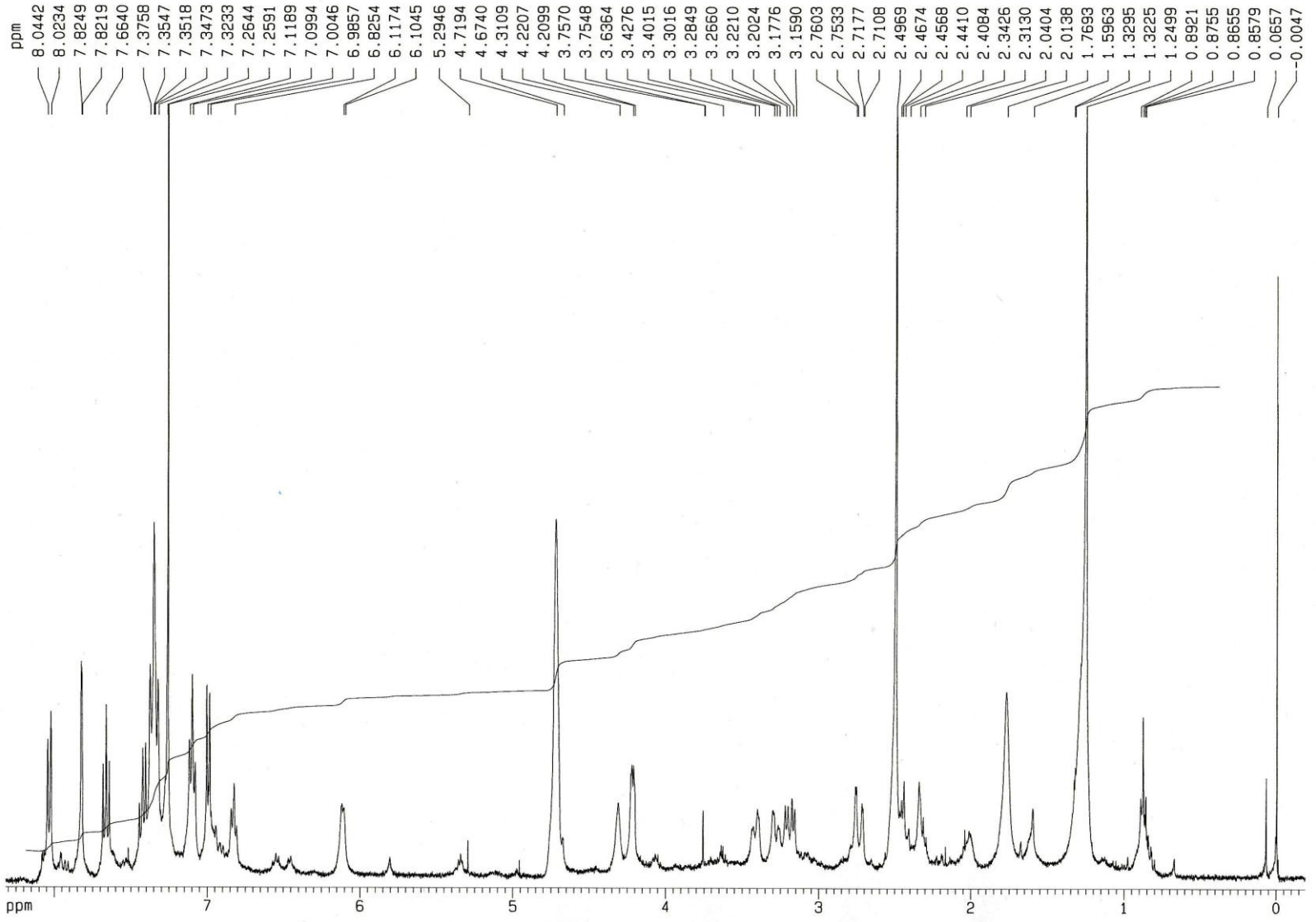


Figure S21. ROESY spectrum of strong complex of receptor 1 with *L*-phenylalanine ($CDCl_3$).

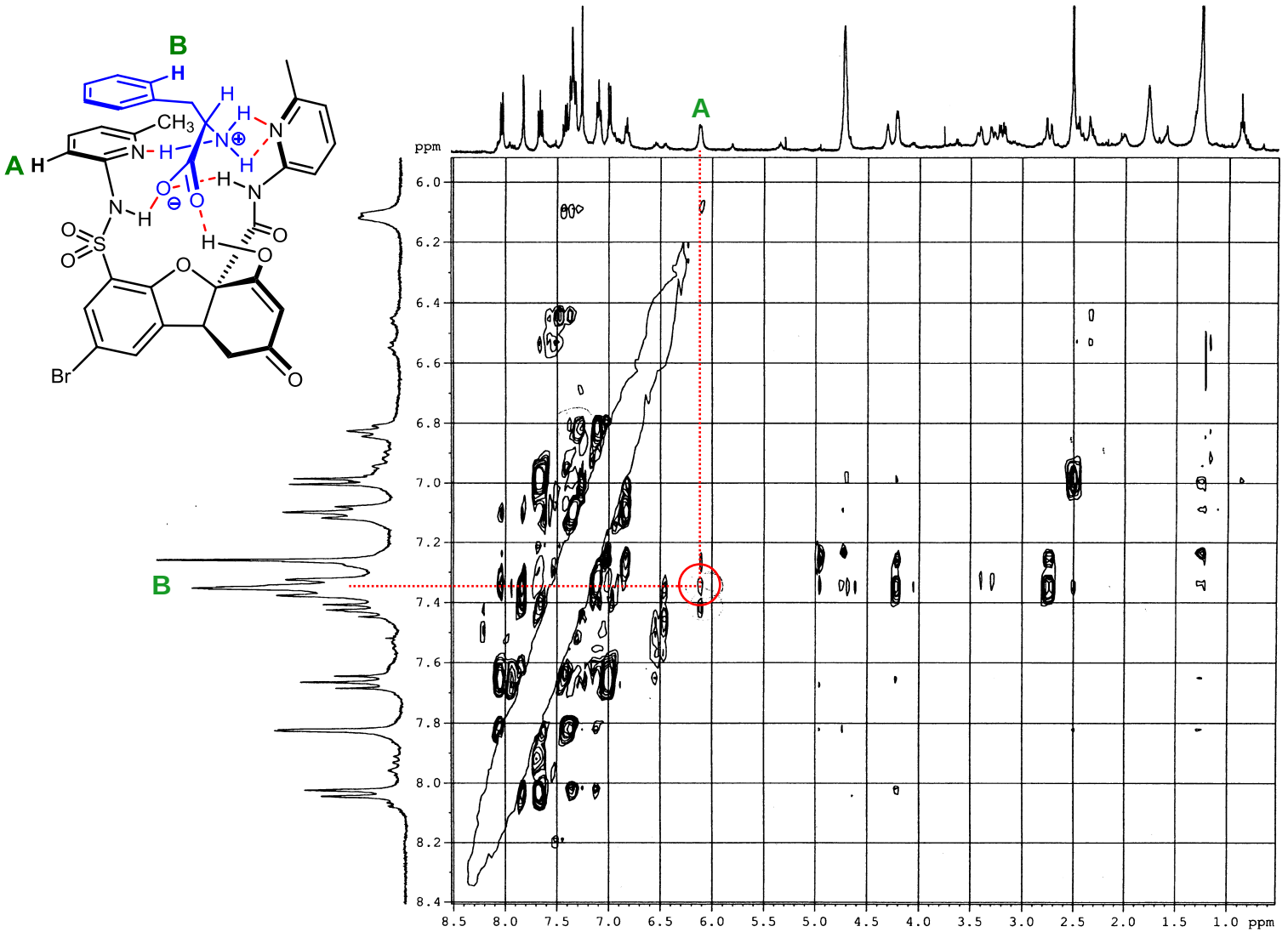


Figure S22. HPLC of extraction of racemic phenylalanine with the receptor 1.

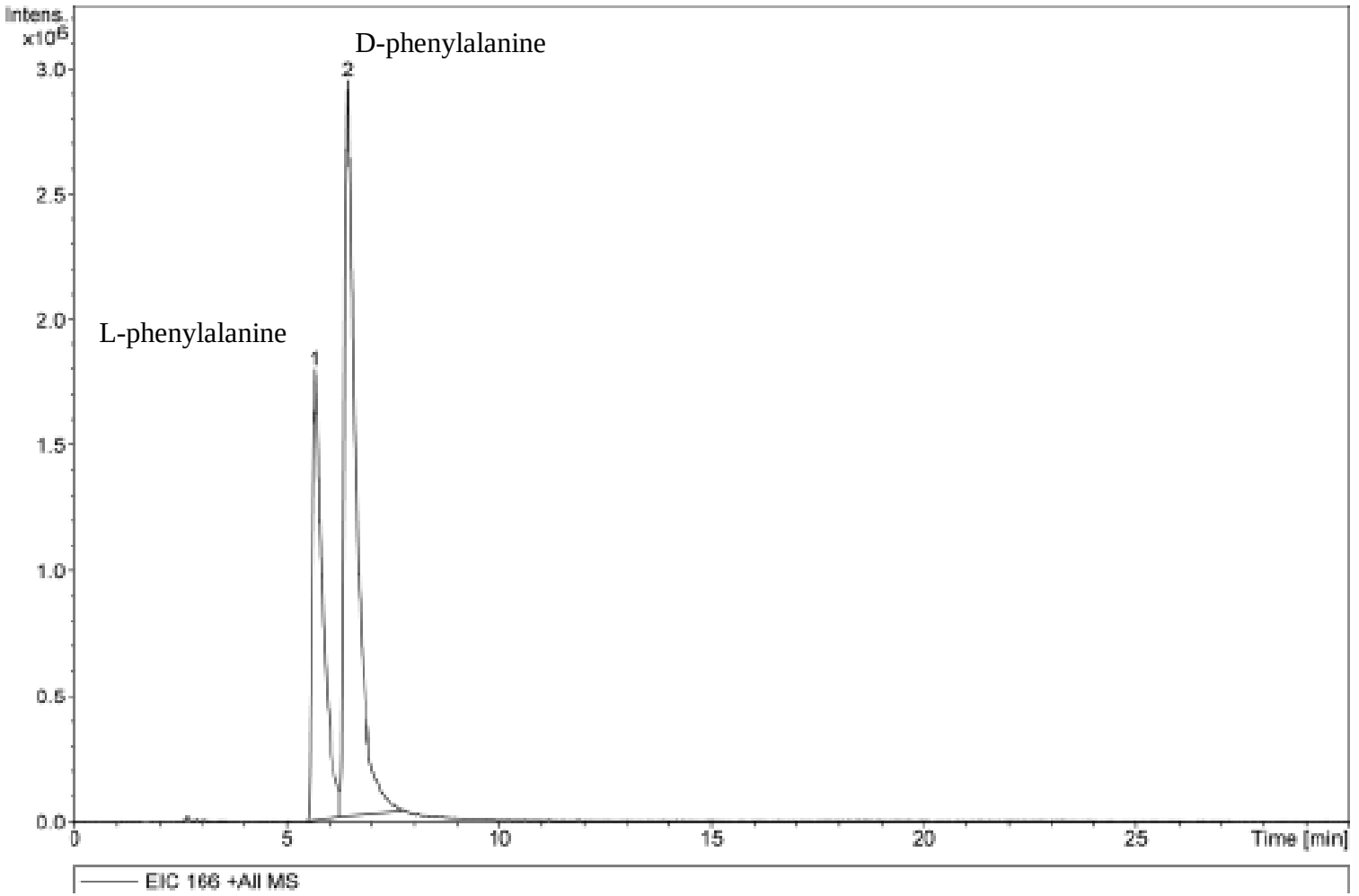
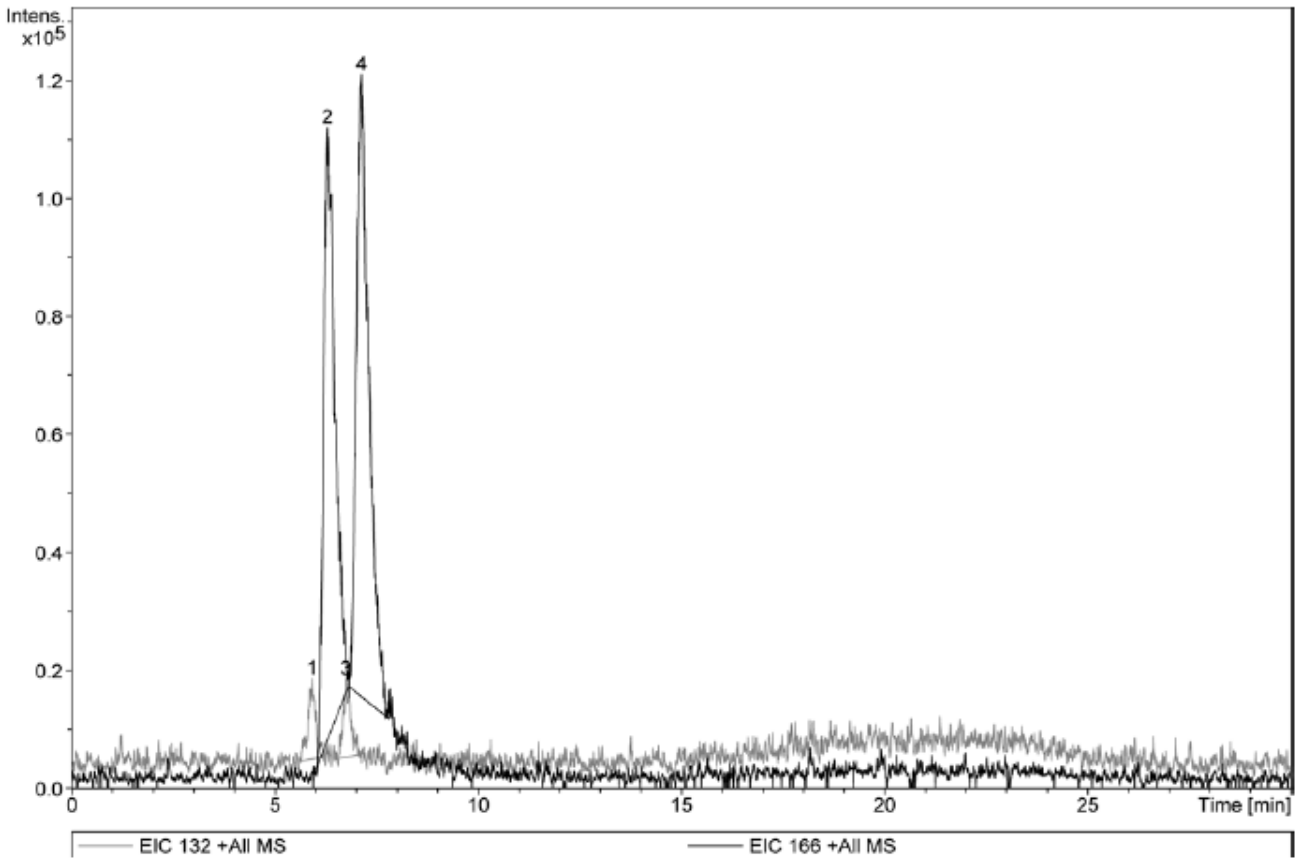


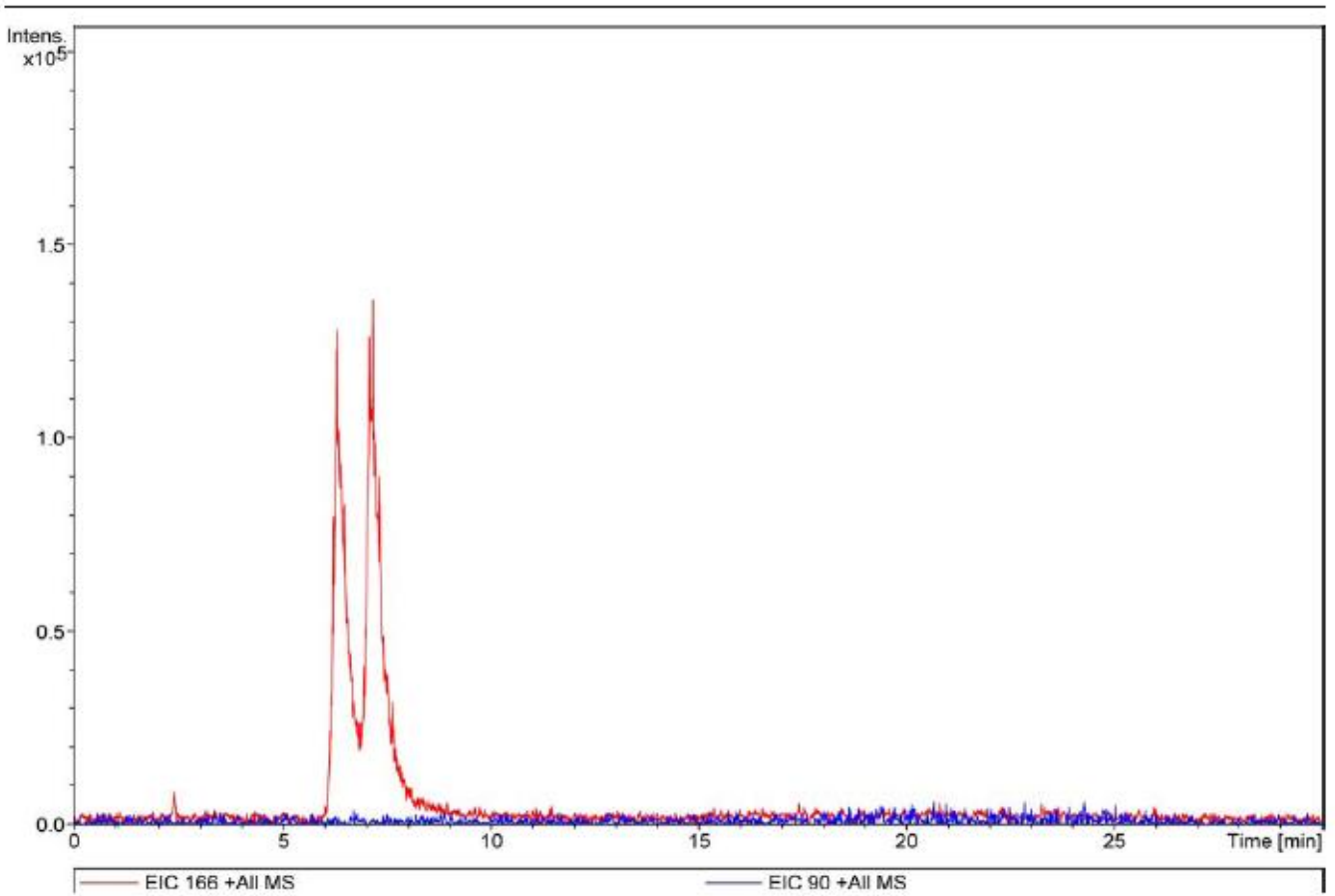
Figure S23. HPLC of extraction of *DL*-phenylalanine and *DL*-leucine with the receptor 1.



Compound List:

#	RT [min]	Range [min]	Height	Area	Area Frac %
1	5.9	5.6 - 6.2	13569	171601	3.7
2	6.3	6.0 - 6.8	103746	2060066	44.1
3	6.7	6.5 - 7.0	13231	159493	3.4
4	7.1	6.8 - 7.8	105429	2275637	48.8

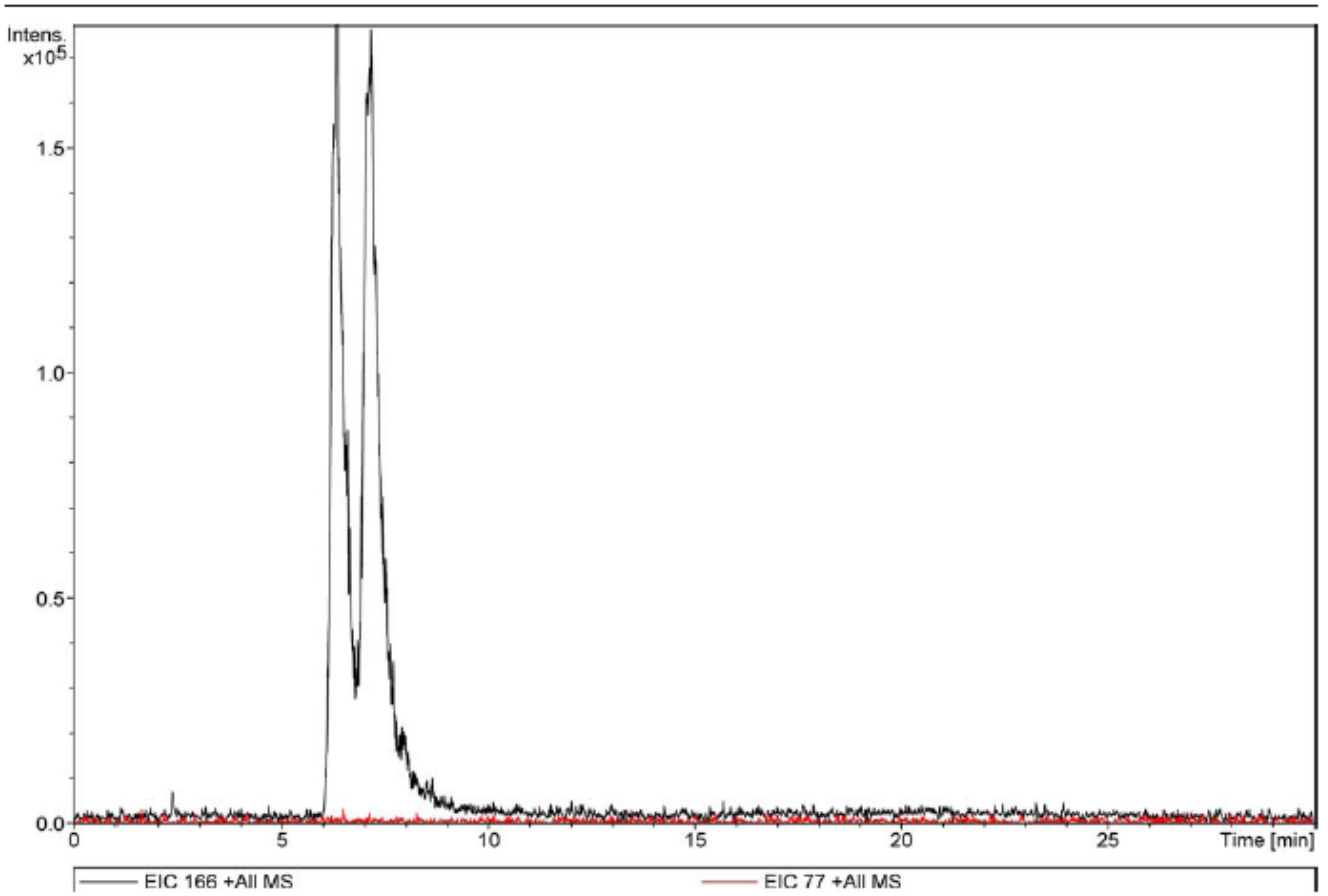
Figure S24. HPLC of extraction of *DL*-phenylalanine and *DL*-alanine with the receptor 1.



Compound List:

#	RT [min]	Range [min]	Height	Area	Area Frac %

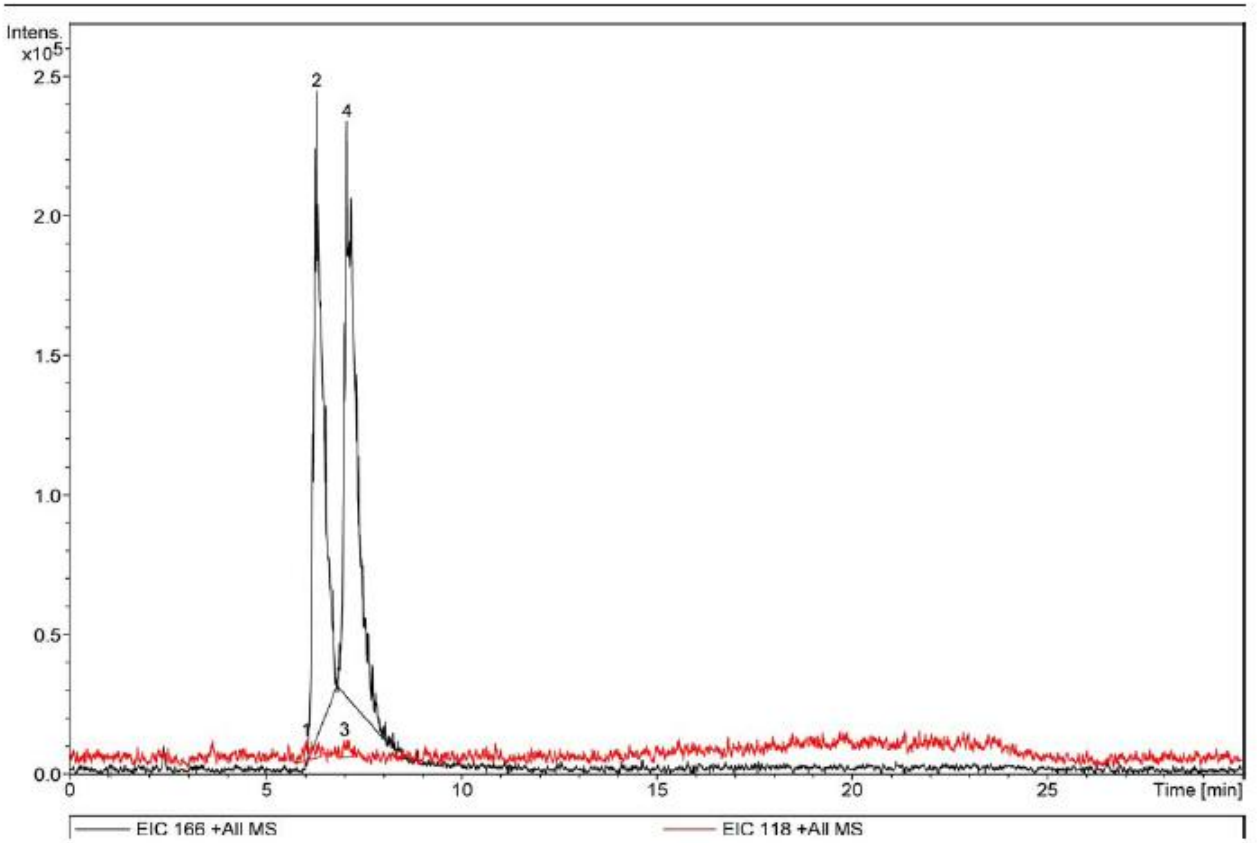
Figure S25. HPLC of extraction of *DL*-phenylalanine and glycine with the receptor 1.



Compound List:

#	RT [min]	Range [min]	Height	Area	Area Frac %

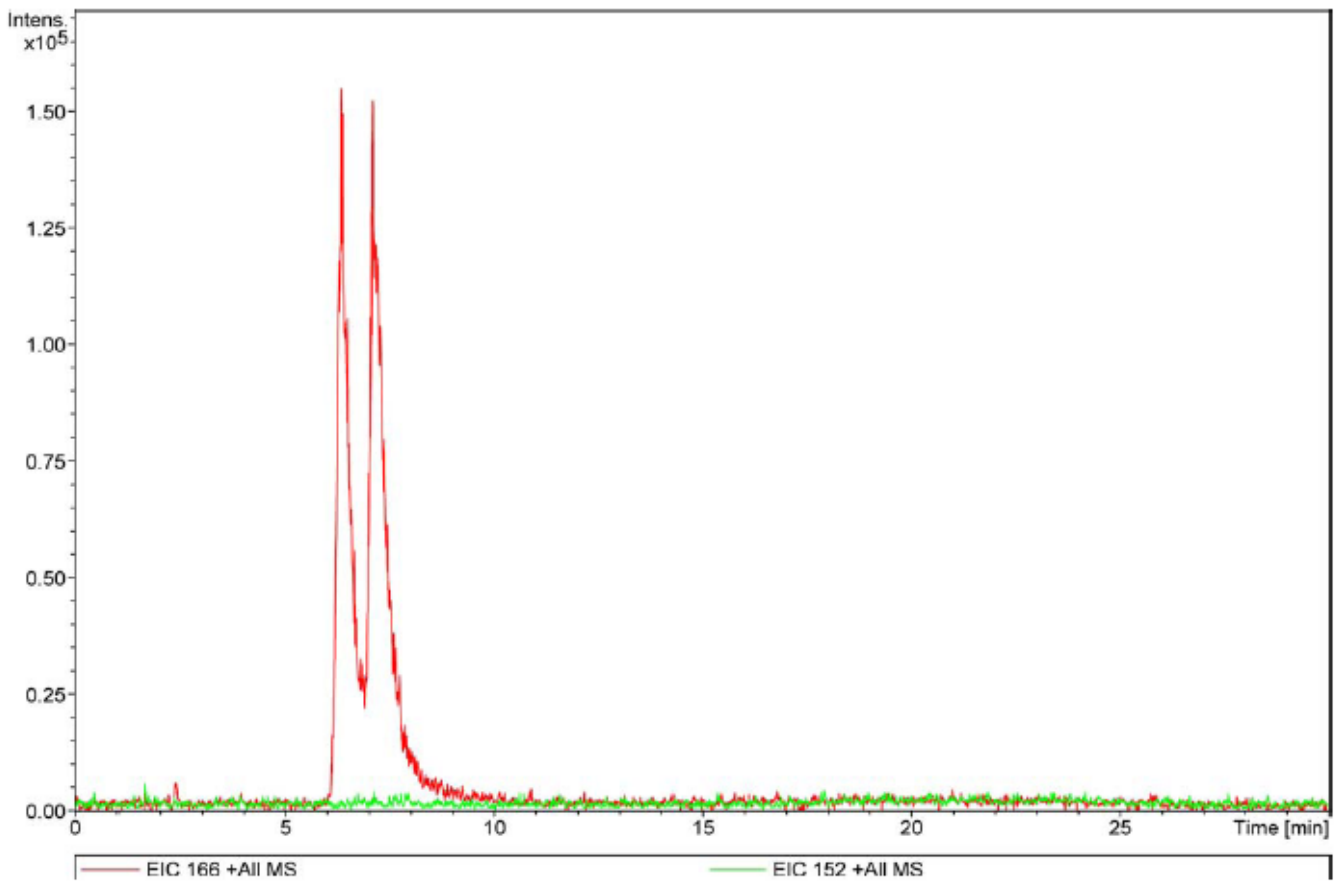
Figure S26. HPLC of extraction of *DL*-phenylalanine and *DL*-valine with the receptor 1.



Compound List:

#	RT [min]	Range [min]	Height	Area	Area Frac %
1	6.0	5.8 - 6.4	7057	109641	1.3
2	6.3	6.0 - 6.8	231830	3782135	46.3
3	7.0	6.8 - 7.3	6259	78253	1.0
4	7.1	6.8 - 8.1	206129	4196467	51.4

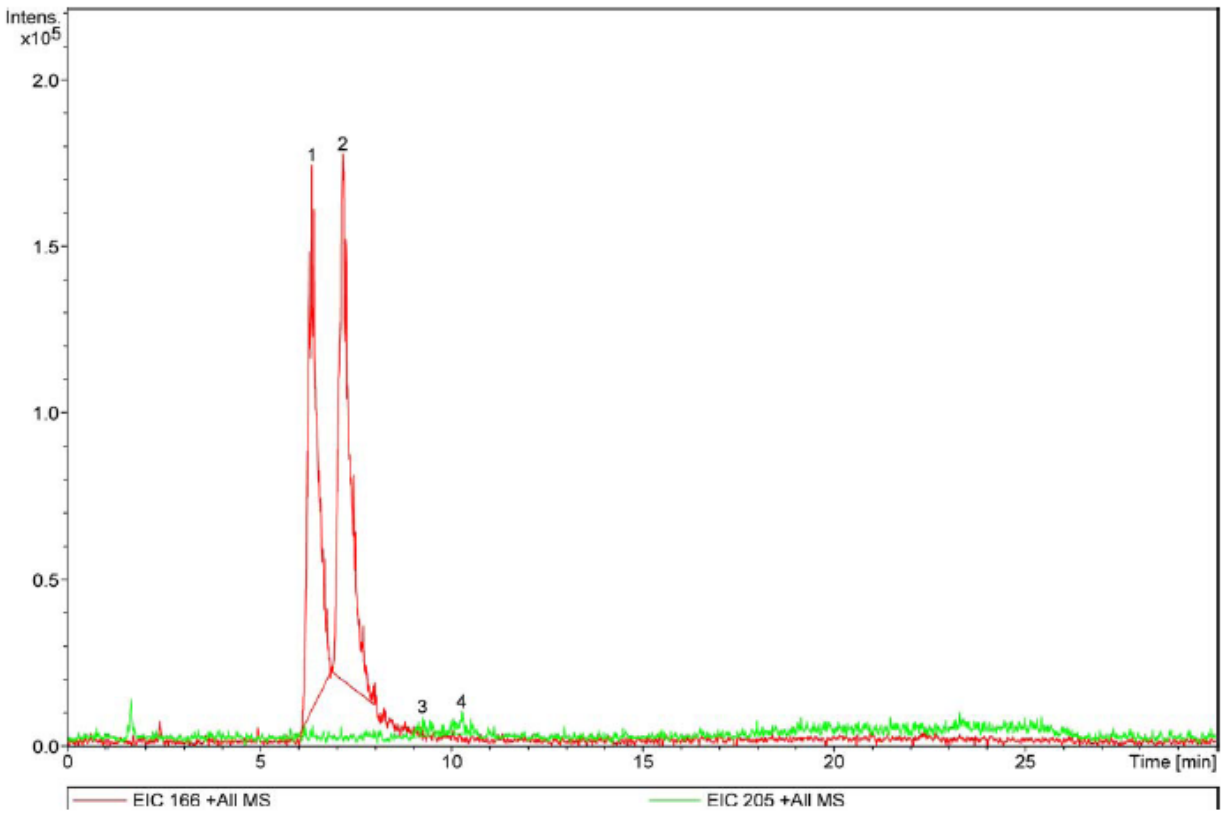
Figure S27. HPLC of extraction of *DL*-phenylalanine and *DL*-phenylglycine with the receptor 1.



Compound List:

#	RT [min]	Range [min]	Height	Area	Area Frac %

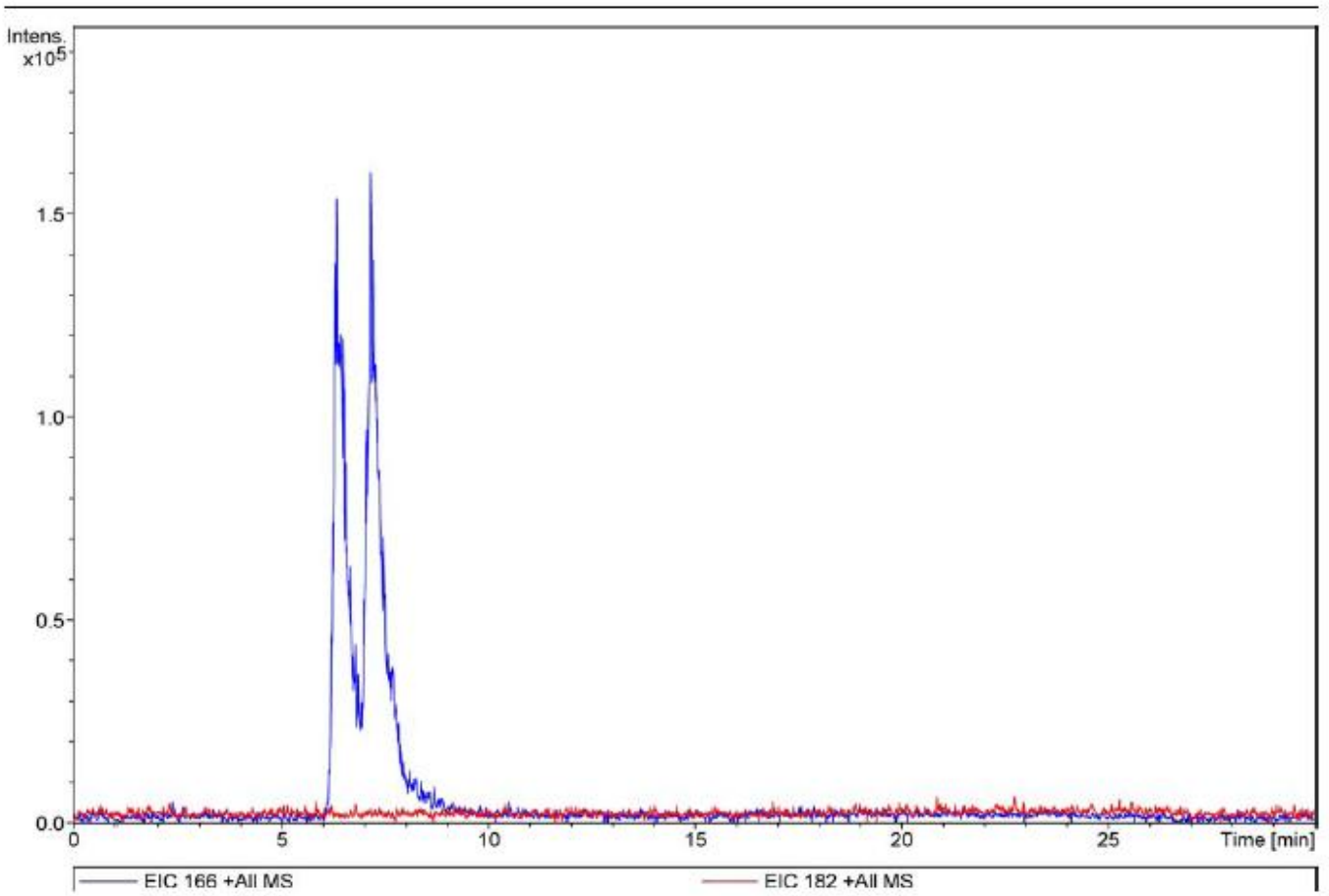
Figure S28. HPLC of extraction of *DL*-phenylalanine and *DL*-tryptophan with the receptor 1.



Compound List:

#	RT [min]	Range [min]	Height	Area	Area Frac %
1	6.3	6.0 - 6.8	163380	2614351	44.7
2	7.2	6.9 - 8.0	157848	3063395	52.4
3	9.2	8.9 - 9.6	5738	77297	1.3
4	10.3	9.8 - 10.6	6538	94775	1.6

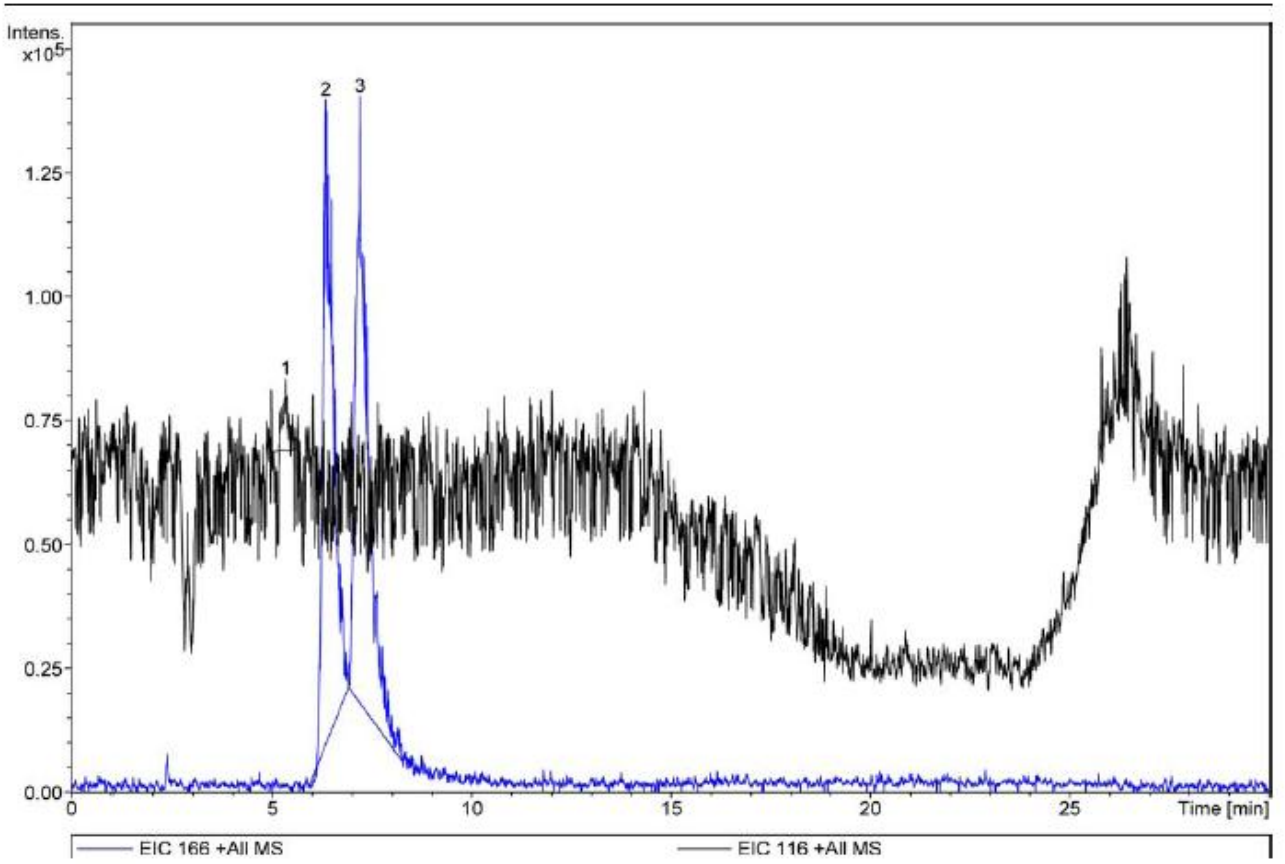
Figure S29. HPLC of extraction of *DL*-phenylalanine and *L*-tyrosine with the receptor 1.



Compound List:

#	RT [min]	Range [min]	Height	Area	Area Frac %

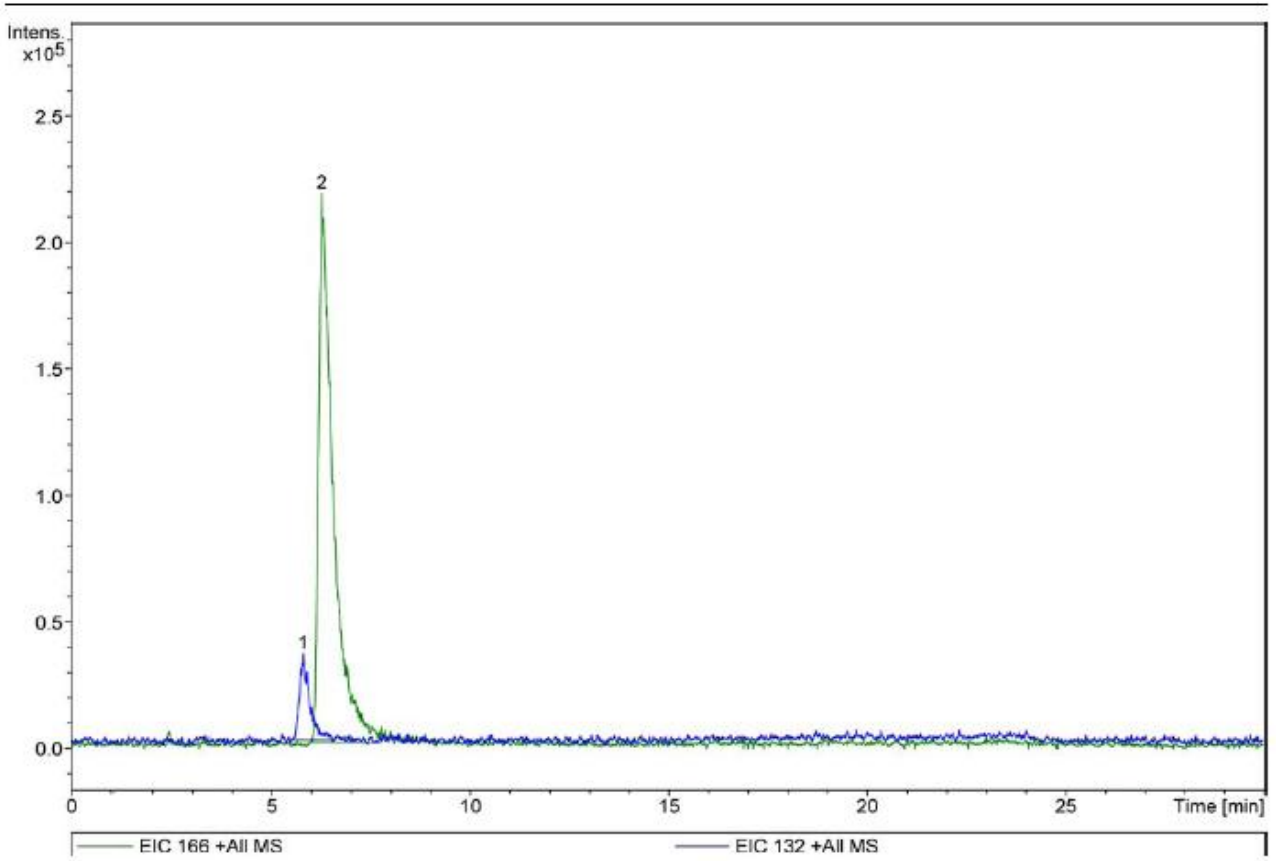
Figure S30. HPLC of extraction of *DL*-phenylalanine and *L*-proline with the receptor 1.



Compound List:

#	RT [min]	Range [min]	Height	Area	Area Frac %
1	5.3	5.0 - 5.6	14418	139387	2.8
2	6.3	5.9 - 6.9	129996	2278896	46.4
3	7.2	6.9 - 8.2	122380	2494640	50.8

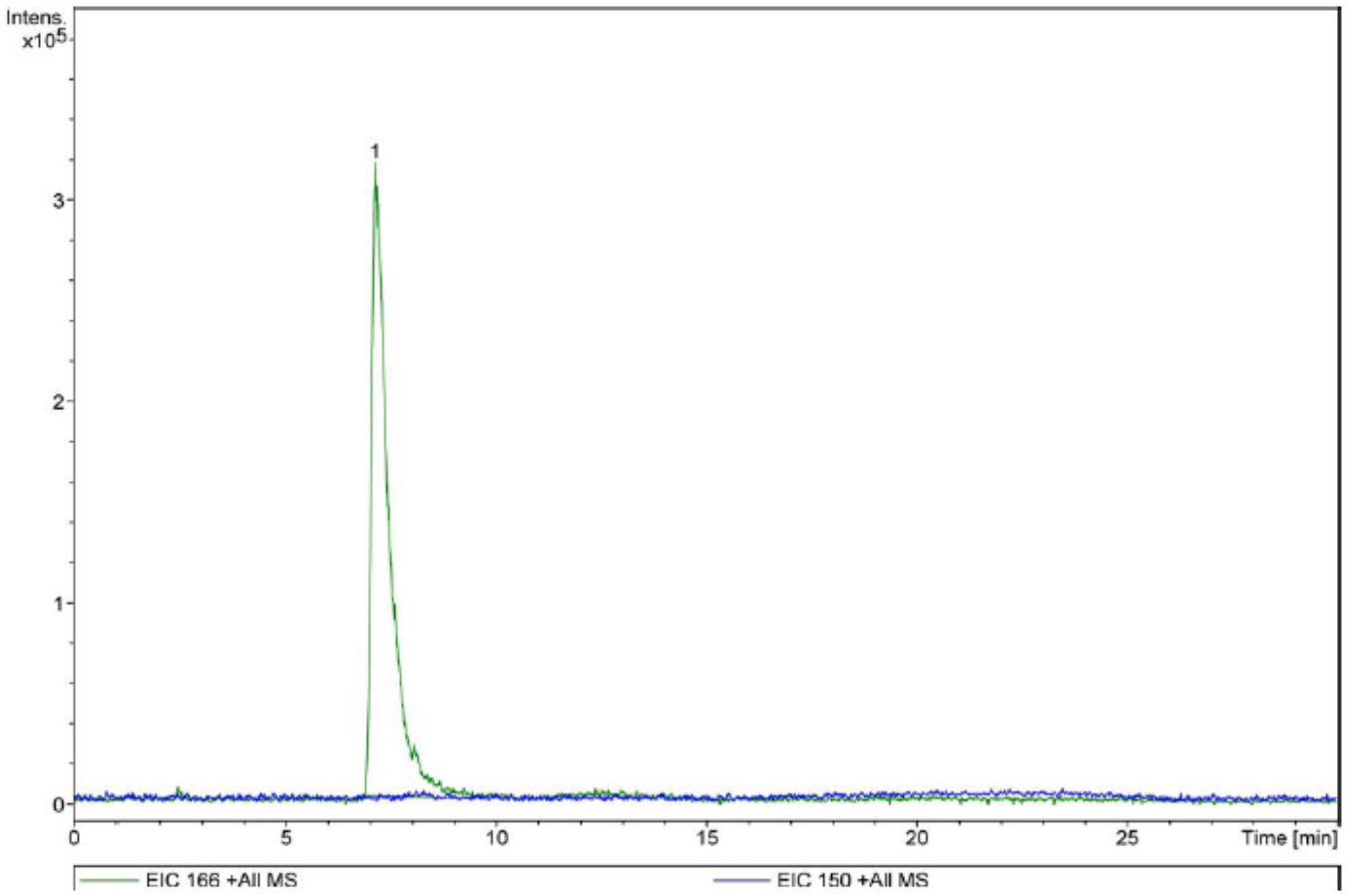
Figure S31. HPLC of extraction of *L*-phenylalanine and *L*-isoleucine with the receptor 1.



Compound List:

#	RT [min]	Range [min]	Height	Area	Area Frac %
1	5.8	5.5 - 6.5	34334	594900	9.7
2	6.3	6.0 - 7.7	217015	5558542	90.3

Figure S32. HPLC of extraction of *L*-phenylalanine and *L*-methionine with the receptor 1.



Compound List:

#	RT [min]	Range [min]	Height	Area	Area Frac %
1	7.1	6.7 - 9.4	314477	9118080	100.0

Figure S33. Circular dichroism spectrum for (2*S*, 3*R*)-receptor 1 (dioxane).

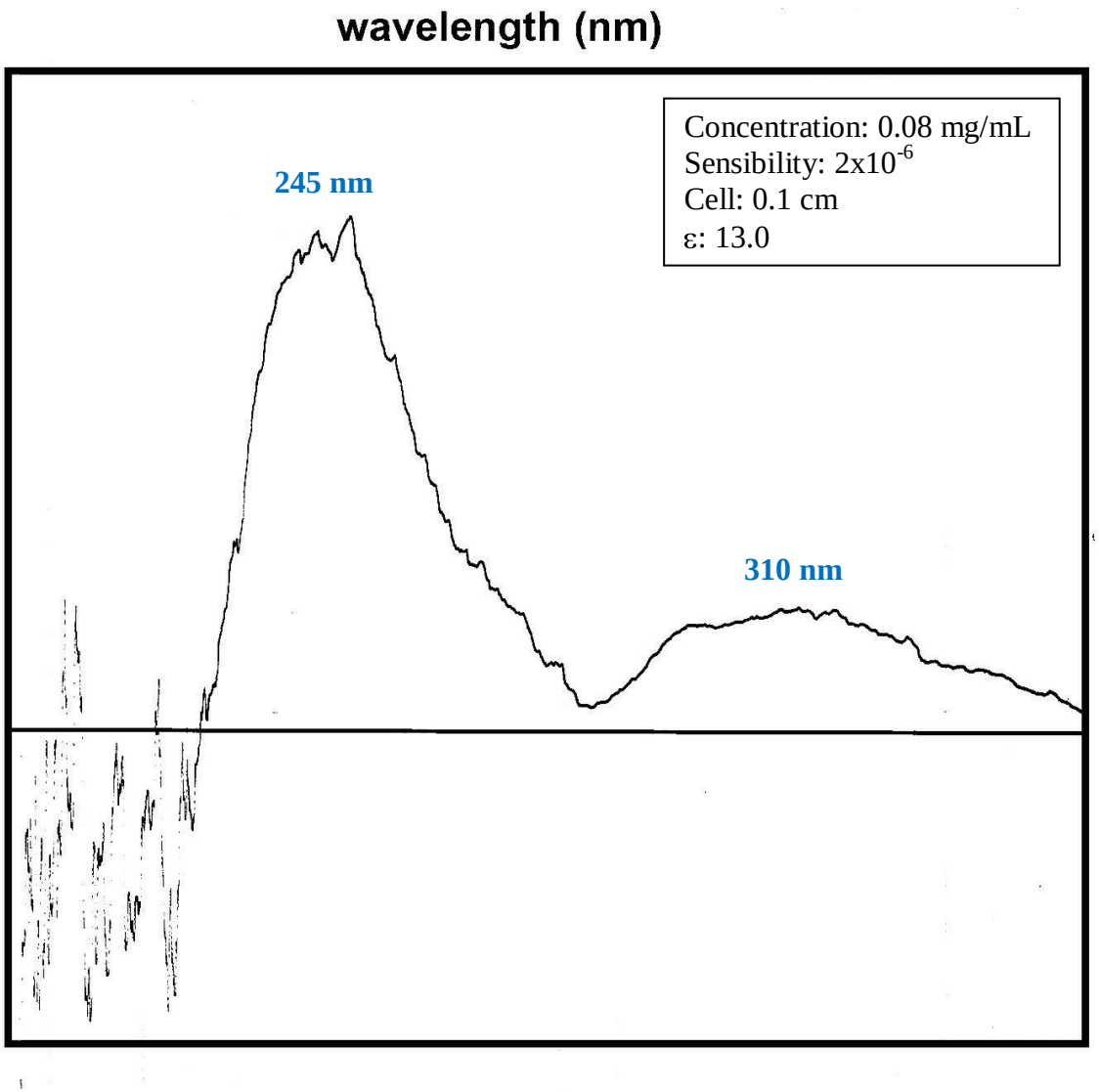


Figure S34. Circular dichroism spectrum for the complex of (2*S*, 3*R*)-receptor 1 and *L*-phenylalanine (CH_2Cl_2).

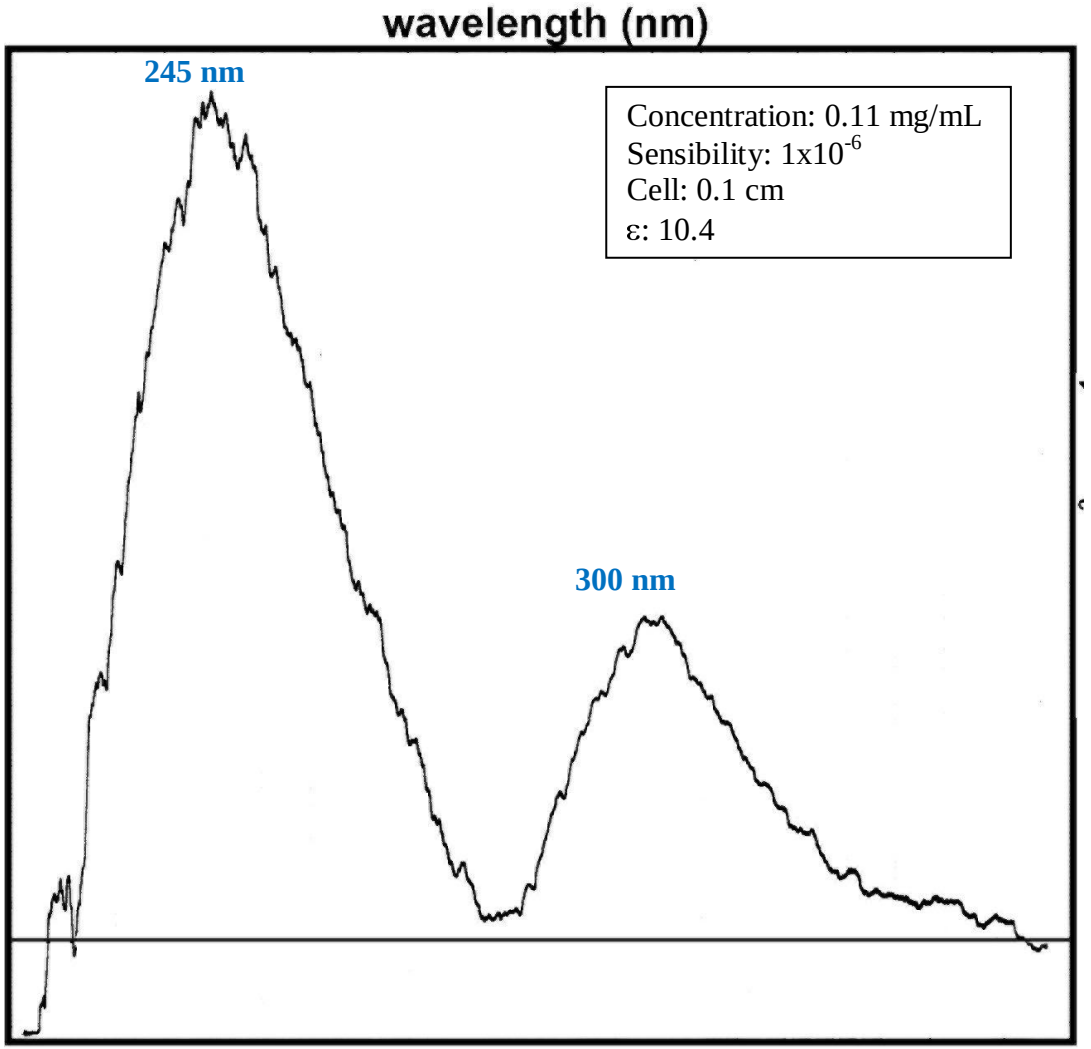


Figure S35. Circular dichroism spectrum for (2*R*, 3*S*)-receptor 1 (dioxane).

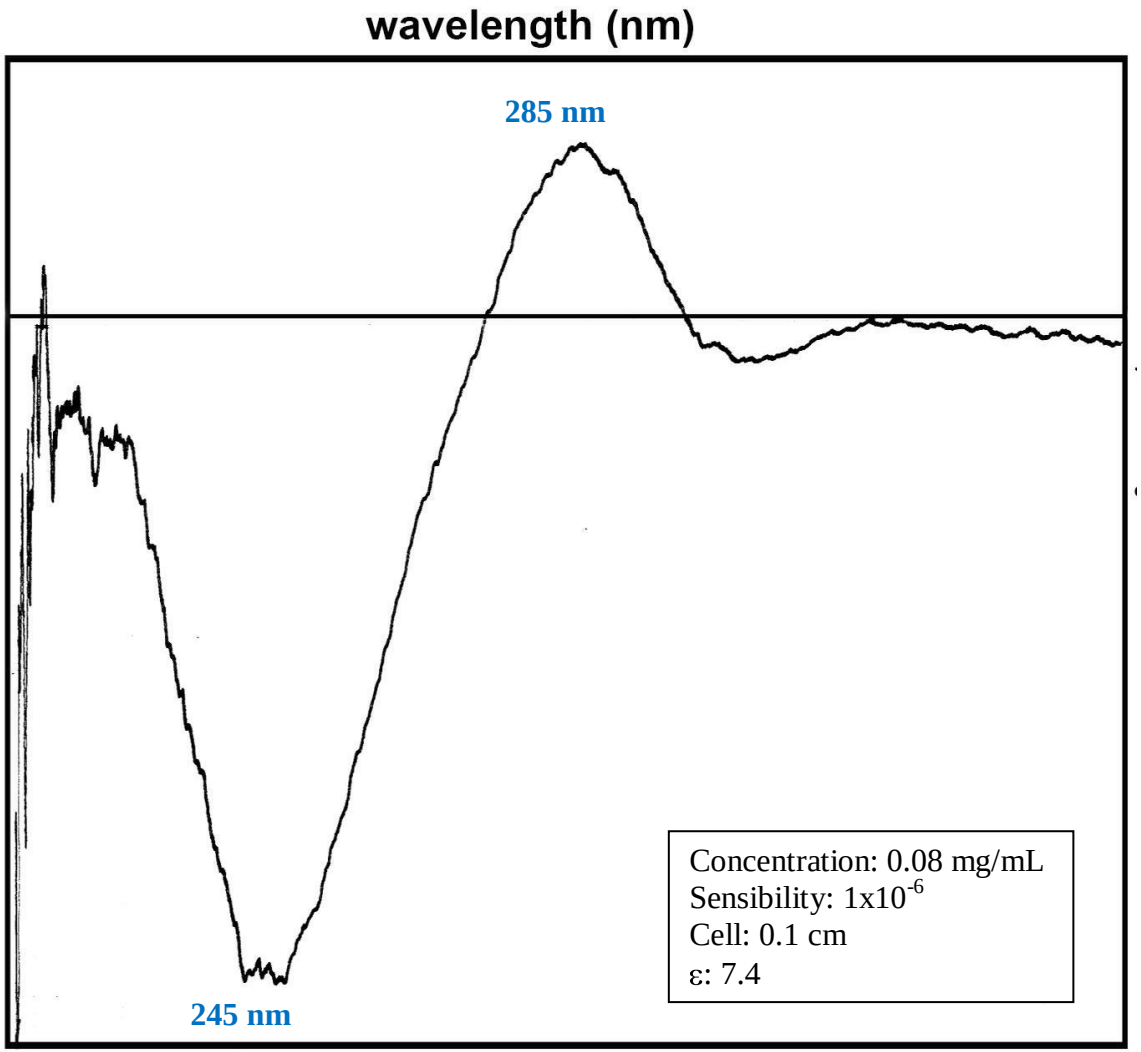


Figure S36. Circular dichroism spectrum for the complex of (2*R*,3*S*)-receptor 1 and *L*-phenylalanine (CH_2Cl_2).

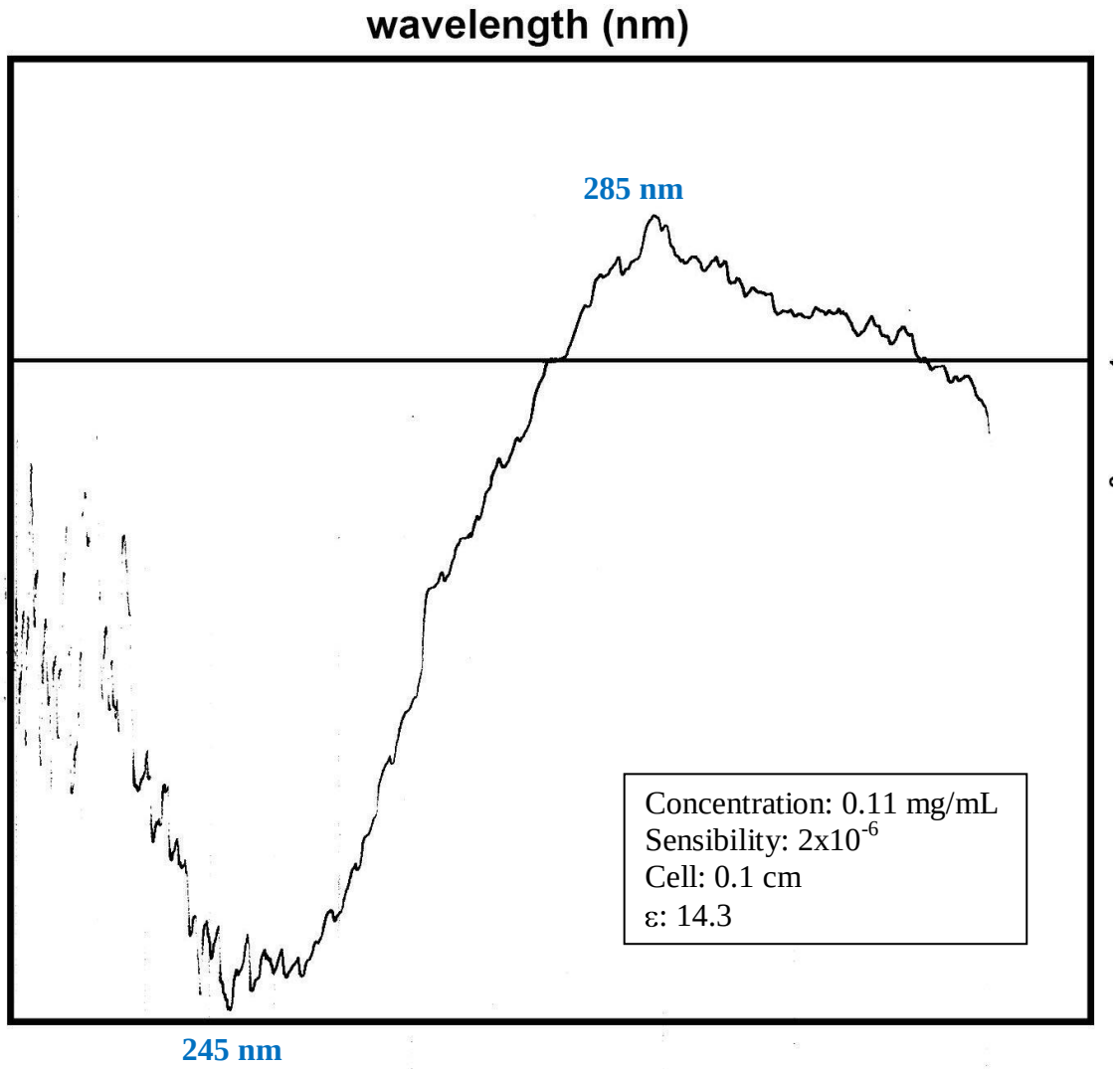
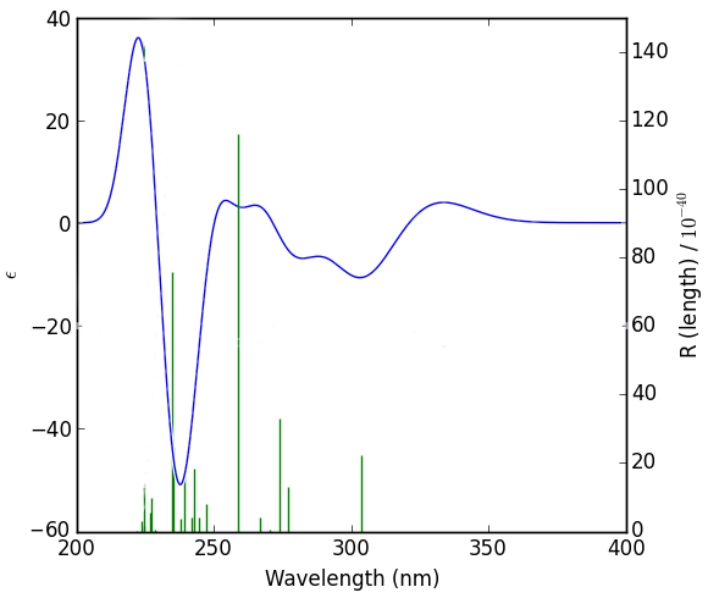


Figure S37. ECD spectra simulation for associates between receptor 1 and *L*-phenylalanine.

All calculations were performed using Gaussian09 software[1]. The structure of the complexes was optimized using M06-2X DFT functional [2] and 6-31G** basis set.[3] A time-dependent DFT calculation, including the 50 more stable singlet excited states, was performed using B98 functional [6] and 6-31G** basis set. This functional was chosen after considering its performance in the Truhlar benchmark database VES21 for electronic excitation energies involving valence excited states.[2] For both structures, the ECD spectra was simulated using a value of σ=0.4 using Gaussum software[7].

ECD spectra for the complex between *L*-phenylalanine and (2*R*,3*S*) receptor **1**. Comparison with experimental ECD spectra reveal that this absolute configuration corresponds to (-) receptor **1**.



ECD spectra for the complex between *L*-phenylalanine and (2*S*,3*R*) receptor **1**. Comparison with experimental ECD spectra reveal that this absolute configuration corresponds to (+) receptor **1**.

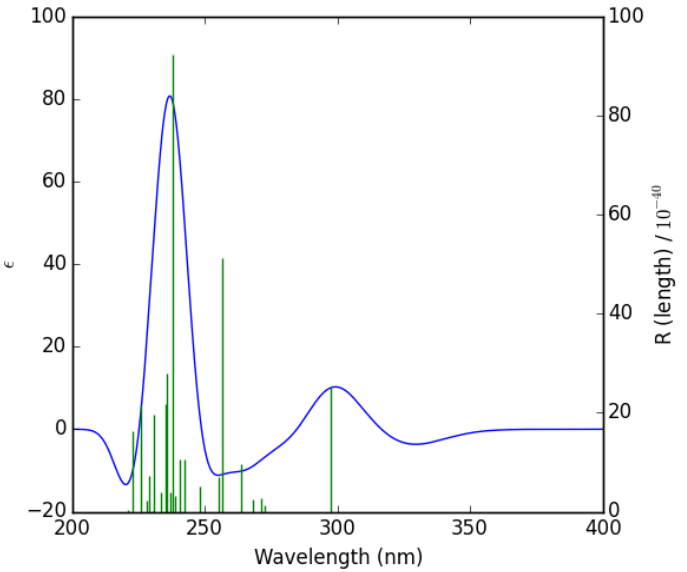


Figure S38. Modelling studies of associates between receptor 1 and *L*-phenylalanine.

All calculations were performed using Gaussian09 software.[1] Since it does not participate in the complex formation and in order to keep the calculations within reasonable limits, the bromine atom in the catalyst structure was substituted by a hydrogen atom. Geometry optimizations were performed using M06-2X DFT functional[2] and 6-31G** basis set[3] in the gas phase. Gibbs free energy correction at 298.15 K was calculated with this method and corrected according to the so-called "quasi-harmonic approach" using a free-rotor approximation for vibrational modes below 100 cm^{-1} and a rigid rotor approximation above this cutoff.[4] Single point energy was calculated on the optimized structures using M06-2X DFT functional[2] and 6-311+G** basis set. Solvent (chloroform) was modeled in this single-point calculation using SMD solvation model.[5] The Gibbs free energy of each structure is calculated adding to this single point energy the ΔG correction term calculated as described above.

Strong complex
ΔG: 0.00 kcal/mol

O	-1.77077	-0.49642	-0.29187
O	-3.55350	2.40108	-1.15114
N	-1.38858	2.21298	-0.40399
C	-2.08709	-4.13404	-0.74738
H	-1.50873	-5.04531	-0.63632
C	-3.40151	-4.16236	-1.19801
C	-4.14313	-2.97966	-1.31650
H	-5.17549	-3.01156	-1.65174
C	-3.54636	-1.77392	-0.99371
C	-4.02227	-0.33919	-1.04922
H	-3.88749	0.03798	-2.07049
C	-5.45519	-0.05798	-0.61405
H	-6.16122	-0.71905	-1.12358
C	-5.68998	-0.18485	0.88242
C	-4.56134	0.09763	1.76673
H	-4.74438	0.07320	2.83501
C	-3.30693	0.32018	1.32448
C	-2.95144	0.33056	-0.15938
C	-2.22636	-1.75447	-0.55513
C	-1.48765	-2.91668	-0.41208
C	-2.65726	1.76140	-0.63039
H	-0.72588	1.59458	0.08622
H	-5.70069	0.97181	-0.89460
C	-0.91171	3.49615	-0.66683
C	-1.71598	4.53864	-1.15587
C	0.95415	4.86818	-0.59852
C	-1.12062	5.77103	-1.35536

H	-2.76098	4.36353	-1.35792
C	0.23124	5.95262	-1.07462
H	-1.71728	6.59801	-1.72707
H	0.71537	6.91135	-1.21890
C	2.42225	4.98993	-0.28135
H	3.01936	4.37367	-0.96299
H	2.76093	6.02156	-0.38395
H	2.62460	4.66886	0.74594
N	0.39291	3.66362	-0.40372
O	-2.31259	0.55944	2.16858
O	-6.79228	-0.47690	1.30796
H	-3.86039	-5.11266	-1.44584
C	2.24195	1.71155	1.96815
H	2.40241	0.89925	-0.01533
N	2.40916	1.83052	0.48986
S	0.11026	-2.89043	0.35112
O	-0.05237	-2.55453	1.75178
O	0.80276	-4.10769	-0.04668
N	0.85274	-1.57361	-0.33538
H	0.69084	-0.71706	0.22620
H	1.61136	2.40390	0.10461
C	1.88227	-1.55097	-1.26294
C	2.17265	-2.61688	-2.13160
C	3.21546	-2.45307	-3.02100
H	1.60097	-3.53241	-2.08536
C	3.56538	-0.25044	-2.17082
C	3.93264	-1.25638	-3.05111
H	3.46734	-3.25854	-3.70372
H	4.74969	-1.10365	-3.74636
N	2.56129	-0.39907	-1.29055
C	4.28442	1.07106	-2.14036
H	3.57055	1.89680	-2.23191
H	4.82791	1.17476	-1.19359
H	5.00536	1.15095	-2.95515
C	0.93661	0.93754	2.26976
O	0.70427	0.68460	3.43601
O	0.22814	0.65801	1.23018
H	-1.40174	0.40485	1.80407
H	3.29097	2.29092	0.25903
C	3.46113	1.06436	2.62789
H	3.16886	0.88450	3.66618
H	4.30212	1.76806	2.63059
C	3.87079	-0.21753	1.94115
C	5.01315	-0.24546	1.13635
C	3.09138	-1.37410	2.05378
C	5.36746	-1.39713	0.43707
H	5.64282	0.64123	1.07380
C	3.45377	-2.53046	1.36703
H	2.19977	-1.37445	2.67747
C	4.58175	-2.54091	0.54787
H	6.25492	-1.40078	-0.18892
H	2.83979	-3.42171	1.45820
H	4.84689	-3.44054	0.00169
H	2.10354	2.72699	2.35612

Weak Complex

ΔG: 1.2 kcal/mol

O	-1.64820	0.39295	-0.17957
O	0.21210	2.88874	-1.87826
N	0.93145	0.91092	-0.96050
C	-5.12989	-0.80976	-0.10972
H	-5.72738	-1.62366	0.28776

C	-5.70539	0.20137	-0.86882
C	-4.92655	1.26109	-1.34810
H	-5.38289	2.06346	-1.92018
C	-3.57023	1.27557	-1.07765
C	-2.46463	2.22185	-1.48030
H	-2.14280	1.97360	-2.49928
C	-2.77835	3.71313	-1.42410
H	-3.71169	3.93946	-1.94623
C	-2.87584	4.27839	-0.01736
C	-2.03747	3.66237	1.01083
H	-2.01673	4.13094	1.98837
C	-1.33394	2.53075	0.81317
C	-1.34657	1.77116	-0.50719
C	-2.99818	0.24922	-0.33260
C	-3.76057	-0.78933	0.17851
C	0.02219	1.90560	-1.18428
H	0.70164	0.20273	-0.25589
H	-1.97072	4.25088	-1.93107
C	2.20151	0.82860	-1.53901
C	2.66749	1.73351	-2.50672
C	4.16166	-0.40229	-1.64167
C	3.92527	1.51600	-3.04015
H	2.05514	2.56665	-2.81077
C	4.69192	0.43758	-2.61279
H	4.30967	2.19798	-3.79205
H	5.68169	0.25074	-3.01339
C	4.94018	-1.58952	-1.14176
H	4.54141	-2.52362	-1.55087
H	5.98925	-1.51694	-1.43407
H	4.89961	-1.63860	-0.05067
N	2.93857	-0.20880	-1.11946
O	-0.55651	2.01895	1.76124
O	-3.58850	5.23700	0.21431
H	-6.76944	0.17691	-1.07412
C	2.18857	-1.59189	2.46585
H	1.41095	-2.35843	0.63073
N	2.31616	-1.99710	1.03125
S	-3.12267	-1.93946	1.37382
O	-2.92856	-1.24272	2.62628
O	-3.95084	-3.13074	1.28567
N	-1.58638	-2.30917	0.86594
H	-0.89042	-1.60657	1.18729
H	2.55397	-1.18664	0.39742
C	-1.25569	-2.97653	-0.30644
C	-2.20175	-3.59207	-1.14279
C	-1.73813	-4.22243	-2.28131
H	-3.25223	-3.58181	-0.88470
C	0.49046	-3.61377	-1.67933
C	-0.37359	-4.23627	-2.56811
H	-2.44266	-4.70513	-2.95124
H	0.01311	-4.71965	-3.45744
N	0.05835	-2.99867	-0.56578
C	1.97566	-3.58316	-1.91129
H	2.32693	-2.54679	-1.89068
H	2.49841	-4.14452	-1.12762
H	2.23945	-4.02604	-2.87310
C	0.94049	-0.69768	2.62173
O	0.32894	-0.44866	1.51382
O	0.69507	-0.27877	3.73528
H	-0.38385	1.03659	1.66978
H	3.03752	-2.70792	0.90351
C	3.42965	-0.84253	2.97059
H	4.29108	-1.52010	3.00761
H	3.18397	-0.56148	3.99932

C	3.78065	0.37890	2.14399
C	2.87481	1.43617	1.97300
C	5.02653	0.46165	1.51878
C	3.18887	2.50387	1.13889
H	1.92869	1.44951	2.50388
C	5.34694	1.53744	0.69264
H	5.75981	-0.32522	1.68428
C	4.41797	2.55182	0.48340
H	2.46135	3.29885	1.00377
H	6.31864	1.57771	0.20930
H	4.65488	3.38326	-0.17278
H	2.03724	-2.50221	3.05232

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