Electronic Supplementary Information for

Hierarchy of π-Stacking Determines the Conformational Preference of Bis-Squaramates

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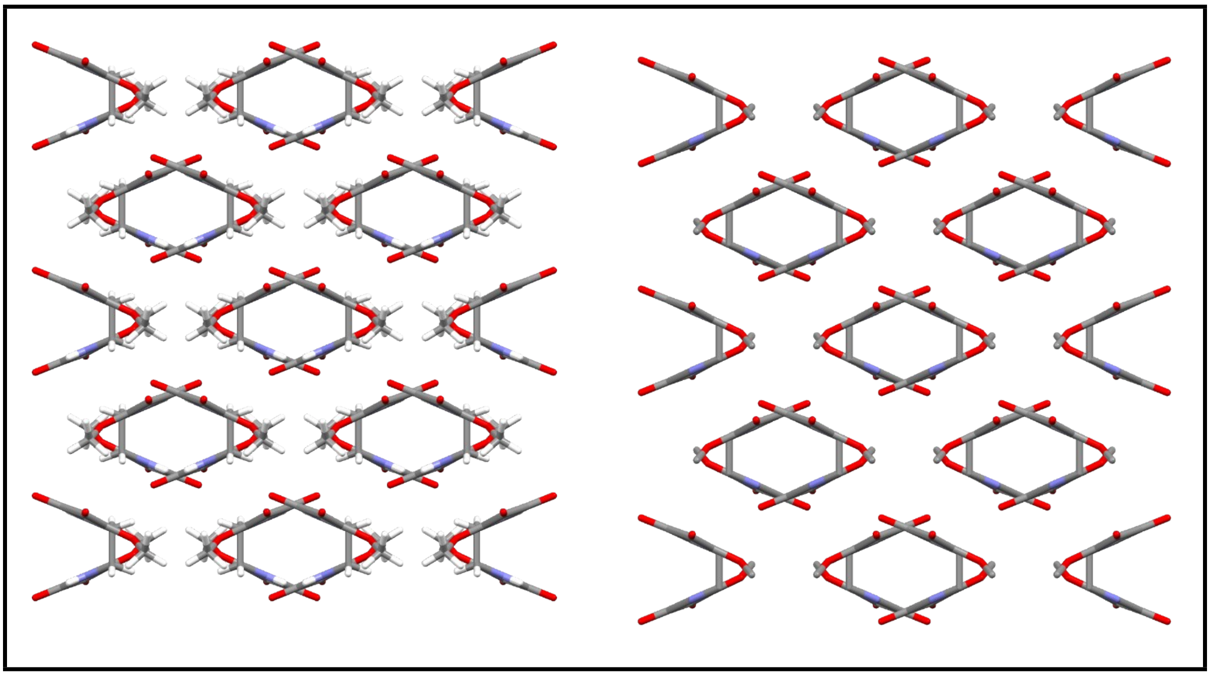

Figure S1. Columnar arrangement of **1** as viewed along the c-axis with inter-tube π-stacking and C–H···O interactions. The left and the right panels are with and without hydrogen atoms.

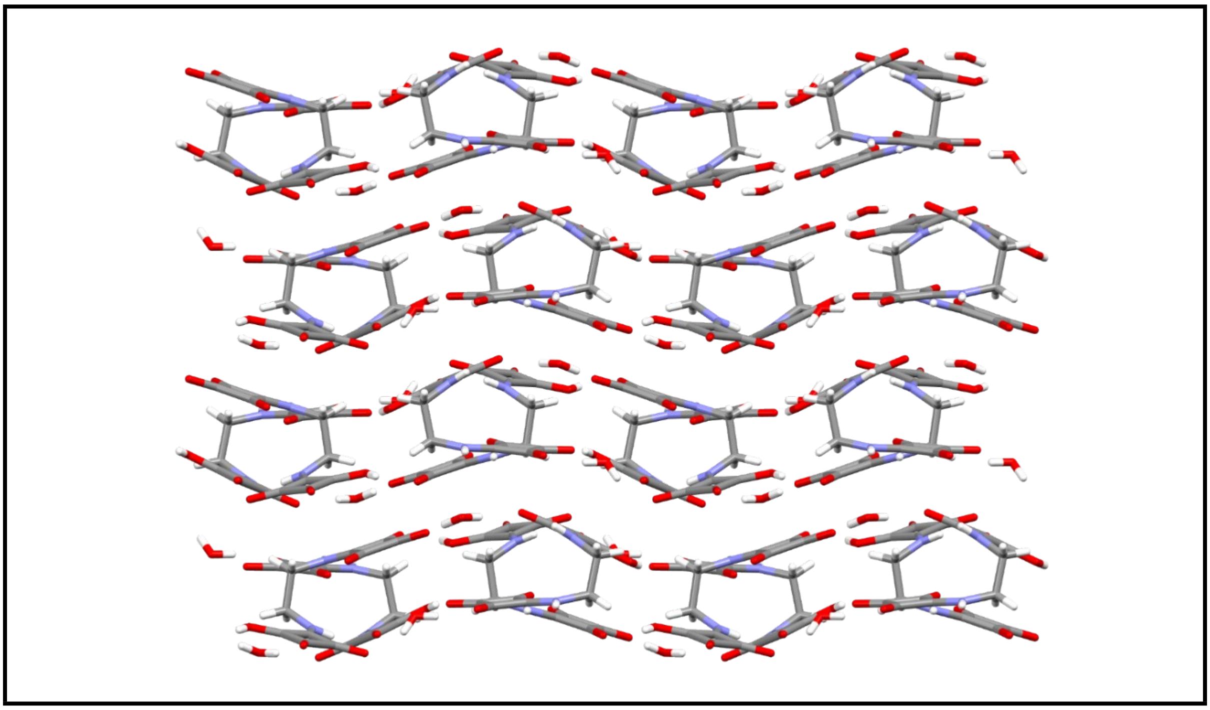

Figure S2. Columnar arrangement of **1′** as viewed along the *a*-axis wherein π-stacking is the predominant inter-planar interaction.

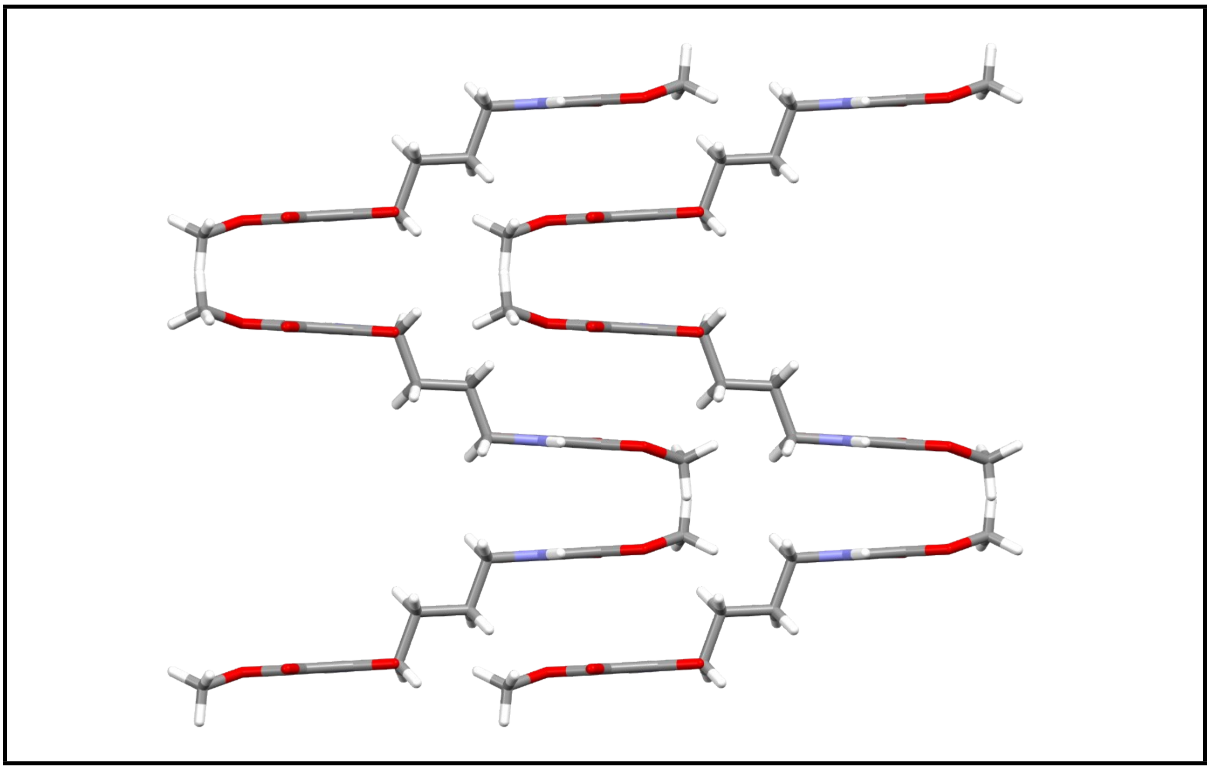

Figure S3. 3D arrangement of interpenetrating zig-structure of **3** as viewed along the *c*-axis wherein π-stacking is the predominant inter-planar interaction along with the presence of C–H⋯O interactions.

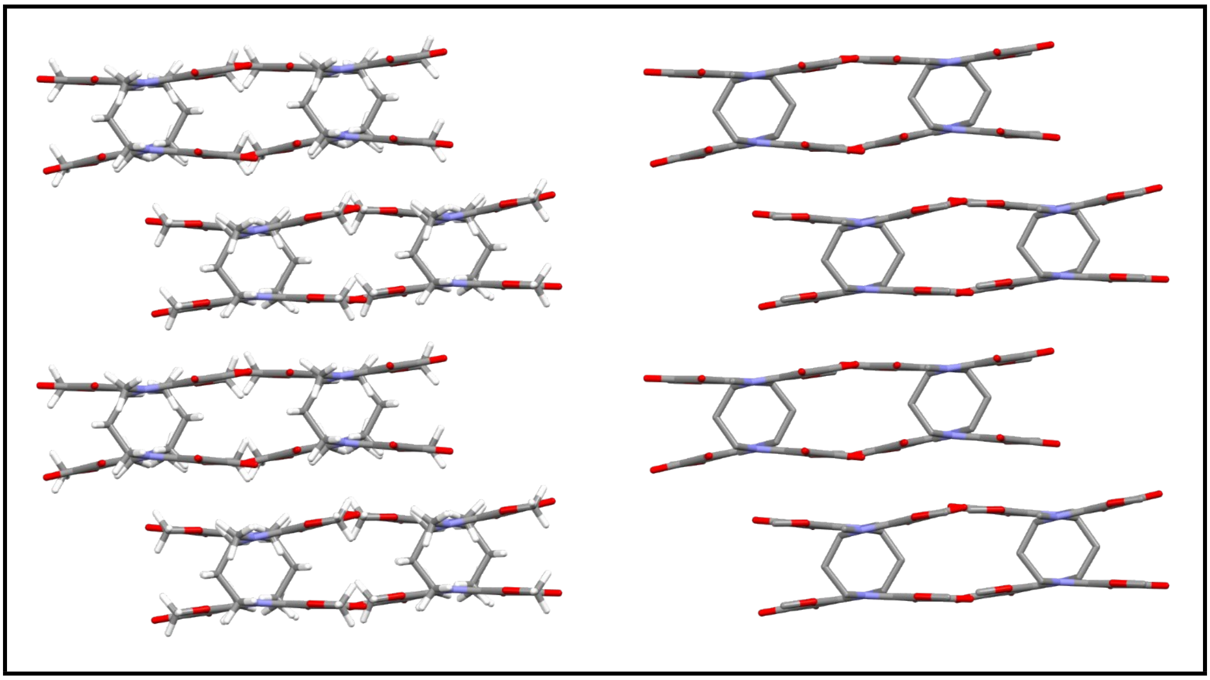

Figure S4. Columnar arrangement of **4** as viewed along the *b*-axis with inter-tube π-stacking and C–H···O interactions. The left and the right panels are with and without hydrogen atoms.

TABLE S1: Crystallographic Parameters

Data	**Sq-1,2-dimer (MeOH+ACN)**	**Sq-1,2-dimer (H_2O+HCl)**	**Sq-1,2-N-methyl-dimer**	**Sq-1,4-dimer**	**Sq-1,3-N-methyl-dimer**
System	**1**	**1’**	**2**	**3**	**4**
CCDC number	1986335	1986336	1986146	1986334	1986337
Formula	0.8(C12 H12 N2 O6)	C20 H18 N4 O14	C14 H16 N2 O6	C7 H8 N O3	2(C15 H18 N2 O6)
Formula weight	224.19	538.38	308.29	154.14	644.63
Colour	colourless	colourless	colourless	colourless	colourless
Crystal morphology	block	block	block	block	block
Crystal size	0.228	0.18	0.311	0.0411	0.21
Temperature/K	123	123	150	150	150
Radiation	Cu K\a	Mo K\a	MoK\a	Mo K\a	MoK\a
Wavelength	1.54184	0.71073	0.71073	0.71073	0.71073
Crystal system	monoclinic	monoclinic	triclinic	monoclinic	triclinic
Space group	*C* 1 2/c 1	*P* 1 21/c 1	*P* -1	*P* 1 21/c 1	*P* -1
***a* (Å)**	9.85680(10)	11.8489(4)	7.8262(3)	8.4828(16)	8.4804(5)
***b* (Å)**	10.16330(10)	15.6629(4)	9.1203(4)	12.528(2)	13.0556(8)
***c* (Å)**	12.28110(10)	11.8621(3)	10.2647(4)	6.6496(11)	13.3103(10)
α (Å)	90	90	79.094(4)	90	84.028(6)
β (Å)	101.6170(10)	93.465(2)	86.345(3)	92.535(16)	86.103(6)
γ (Å)	90	90	79.409(3)	90	89.868(5)
Volume ($Å^3$)	1205.09(2)	2197.44(11)	706.86(5)	706.0(2)	1462.27(17)
Z	5	4	2	4	2
Density (g/cm^{-3})	1.545	1.627	1.449	1.45	1.464
Reflns number gt	1259	5740	2193	1223	2861
Reflns av R equivalents	0.0204	0.0421	0.0492	0.0954	0.0771
F (000)	584	1112.0	324.0	324.0	680
μ	1.081	0.141	0.115	0.115	0.114
***θ* (min, max)**	6.323, 77.539	3.4480, 30.710	2.048, 31.0030	2.8890, 29.5550	2.7650, 29.4320

TABLE S2. Relative energies (kcal mol^{-1}) for bis-squaramates in folded and unfolded conformations calculated using B3LYP functional and 6-31++G(d,p) basis-set with and without long-range dispersion correction.

Systems	**B3LYP**	**B3LYP-D3**	**B3LYP**	**B3LYP-D3**	**Net Dispersion-Stabilization**
	Unfolded		**Folded**		
1	0	-19.4	—	—	—
3	0	-22.7	—	—	—
2	0	-25.6	0.5	-32.5	-6.4
4	0	-27.6	-0.3	-29.7	-6.7

TABLE S3. SAPT0 interaction energy components (kcal mol^{-1}) for assemblies formed by the bis-squaramates calculated using cc-pVTZ basis set. The assemblies are indicated by the appropriate structure in various figures in the main text.

Assembly	E_{Elec}	E_{Ind}	E_{Disp}	E_{Exch}	E_{SAPT0}
1_(Fig_2B)	-35.7	-12.1	-15.7	46.1	-17.5
3_(Fig_3B)	-20.4	-6.3	-12.4	24.7	-14.4
4_(Fig_3D)	-28.6	-9.1	-18.1	43.8	-11.9
3_(Fig_2G)	-31.6	-9.1	-10.6	33.4	-18.0
3_(Fig_2H)	-14.5	-5.6	-12.4	27.2	-5.3

General experimental procedures

Reagents were obtained from commercial suppliers and used as received unless otherwise noted. All the reactions were performed on room temperature. Thin layer chromatography (TLC) was performed on silica coated aluminium plates (0.25 mm thick) and observed under UV light. Column chromatography was performed on silica gel (200-240 mesh). Nuclear magnetic resonance (NMR) spectra were collected using a Bruker DRX- 400 and Bruker DRX-600 with signals reported in ppm and referenced against TMS. NMR spectra are processed using Topspin or MestReNova software. Mass spectrometry (ESI) experiments of the all the compounds were performed on Micromass Platform QMS spectrometer with an electrospray source and a cone voltage of 35 eV, or performed on an Agilent 6220 Accurate Mass LC-TOF system with the Agilent Multimode Source and a capillary voltage of 3500 V. All samples were analysed by dissolving them in Methanol or Dimethyl sulphoxide (DMSO). Agilent MassHunter Qualitative Analysis B.06.00 was used to analyse the spectra and Isotope Distribution Calculator was used to predict specific isotope patterns. X-ray single-crystal data was collected for all the systems on a Rigaku Micromax-007HF High Intensity Microfocus Rotating Anode X-ray Generator using a graphite monochromator Mo Kα or Cu K@ at 133 K. The selected crystals were mounted on the tip of a glass pin using mineral oil and placed in the cold flow produced with an Oxford Cryo-cooling device.

Synthetic protocols

Sq-1,2-dimer (1): Dimethyl squarate (2.96 mmols in 5 ml ether) is mixed slowly with a solution of 1,2-diaminoethane (0.98 mmol in 35 ml ether) was stirred overnight. White precipitate was obtained which was washed with ether (3 times with 15 ml). The precipitate was made soluble in hot methanol and filtered. This process was repeated three times and filtrate was collected. Methanol was then evaporated to obtain white solid powder. Yield= 67%. Single spot on TLC was observed. Compound was further purified using flash column in using 2:8 methanol-DCM mixture. ESI HRMS calculated for $C_{15}H_{18}N_2O_6$ m/z $[M+H]^+$ 281.08. Compound was crystallized by dissolving the powder in MeOH and layering was done by acetonitrile and petroleum ether. Small single crystals suitable for X-ray crystallography were obtained. Further crystal structure of 1 was also obtained by dissolving the compound in 5% $HCl-H_2O$ solvent by vigorous stirring and leaving it on a watch glass overnight under fume-hood.

Sq-1,2-N-methyl-dimer (2): Dimethyl squarate (0.8 mmols in 5 ml diethylether) is mixed dropwise with a solution of N,N'-dimethyl-1,2-diaminopropane (0.4 mmol in 15 ml diethylether) and was stirred overnight on room temperature (RT). An off white precipitate was obtained which was washed with ether (3 times with 15 ml). The precipitate was made soluble in hot methanol and filtered. This process was repeated three times and filtrate was collected. Methanol was then evaporated to obtain white solid powder. Yield= 80%. Single spot on TLC was observed. Powder was purified using flash column chromatography in 5% methanol-DCM mixture. ESI-HRMS calculated for $C_{14}H_{16}N_2O_6$ m/z $[M+H]^+$ 309.1055. Compound was crystallized by dissolving the powder in MeOH and layering was done by acetonitrile and petroleum ether. Small single crystals suitable for X-ray crystallography were obtained.

Sq-1,4-dimer (3): Dimethyl squarate (2.96 mmol in 5 ml ether) is mixed slowly with a solution of 1,4-diaminobutane (0.98 mmol in 35 ml ether) and was stirred overnight. Yellowish precipitate was obtained which was washed with ether (3 times with 15 ml). The precipitate was made soluble in hot methanol and filtered. This process was repeated three times and filtrate was collected. Methanol was then evaporated to obtain white solid powder. Yield= 58%. Three spots on TLC was observed. Pure compound was obtained by using column chromatography in using 2:5:3 methanol-DCM-hexane mixture. ESI HRMS calculated for $C_{14}H_{16}N_2O_6$ m/z $[M+H]^+$ 301.11. Compound was crystallized by dissolving the powder in MeOH and layering was done by acetonitrile and hexane. Single crystals suitable for X-ray crystallography was obtained.

Sq-1,3-N-methyl-dimer (4): Dimethyl squarate (0.8 mmol in 5 ml ether) is mixed slowly with a solution of N,N-dimethyl-1,3-diaminopropane (0.4 mmol in 15 ml ether) was stirred until dimethyl squarate gets consumed fully. An off-white precipitate was obtained which was washed with ether (3 times with 15 ml). The precipitate was made soluble in hot methanol and filtered. This process was repeated three times and filtrate was collected. Methanol was then evaporated to obtain white solid powder. Two spots on TLC were observed. Compounds were separated using column chromatography using 2:5:3 methanol-DCM-hexane mixture. Yield= 75%. ESI HRMS calculated for $C_{12}H_{12}N_2O_6$ m/z $[M+H]^+$ 323.10. Compound was crystallized by dissolving the powder in MeOH and layering was done by acetonitrile and petroleum ether. Single crystals suitable for X-ray crystallography were obtained.

Characterisation data

Sq-1,2-dimer (1):

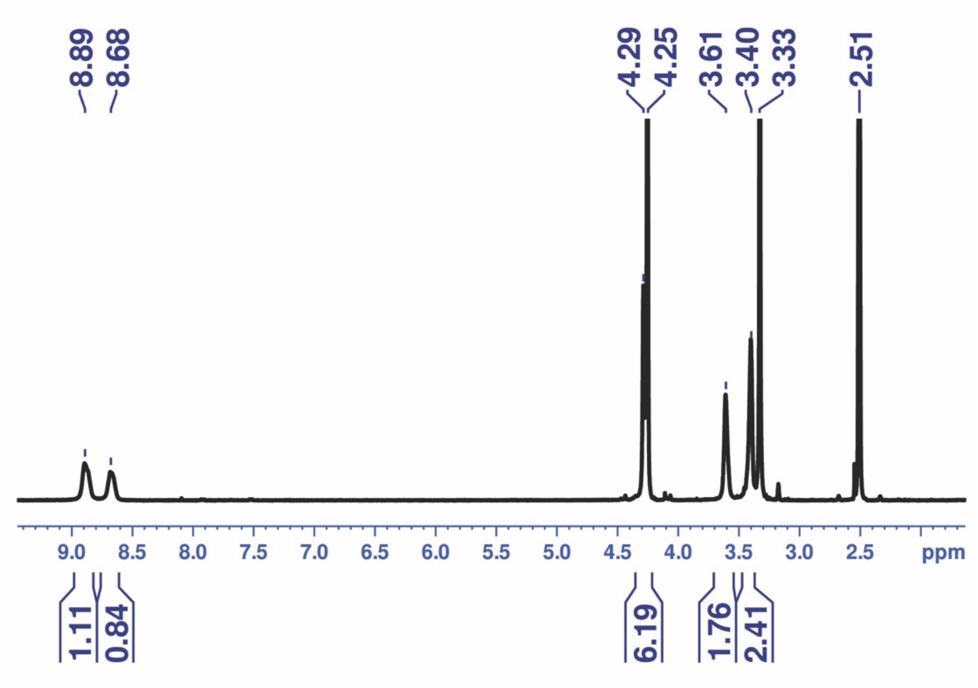

Figure S5: *^{1}H-NMR of **1** recorded in DMSO-d$_6$.*

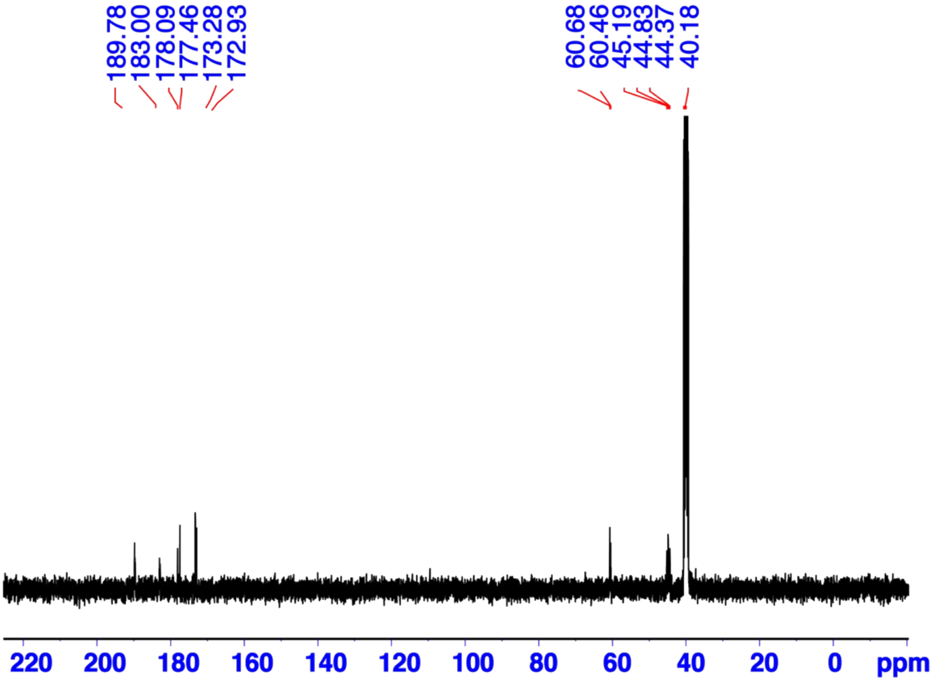

Figure S6: *^{13}C-NMR of **1** recorded in DMSO-d$_6$.*

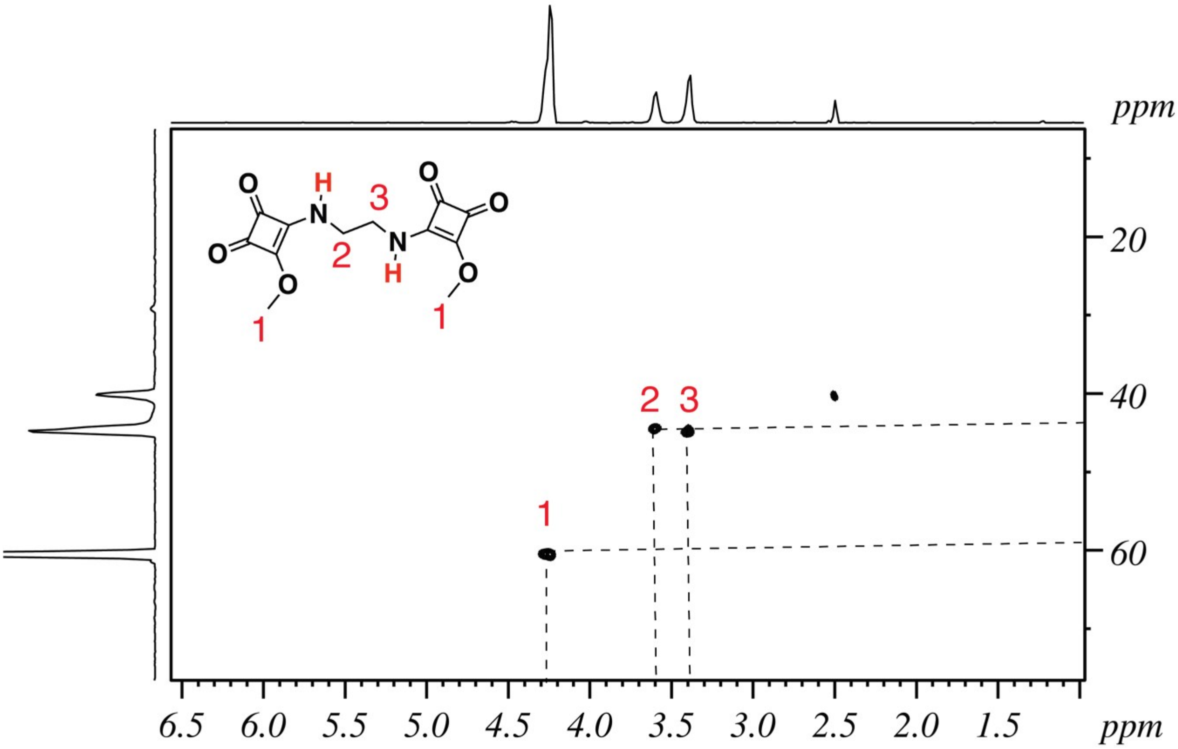

Figure S7: *^{1}H-13C HSQC NMR of **1** recorded in DMSO-d$_{6.}$*

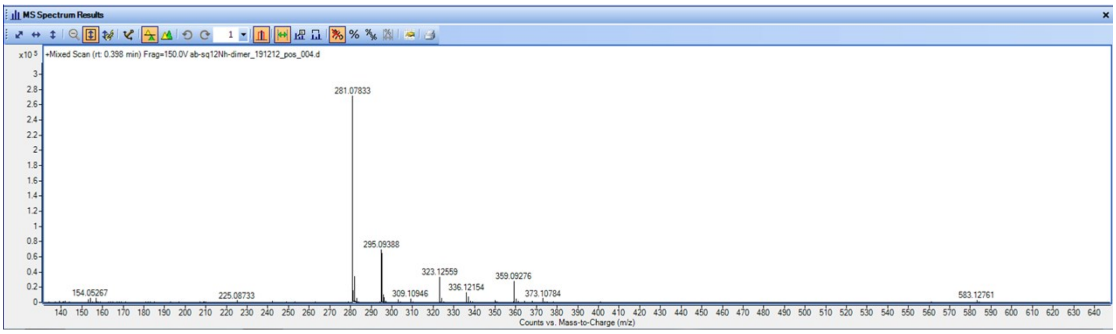

Figure S8: *Mass spectra of 1.*

Sq-1,2-N-methyl-dimer (2):

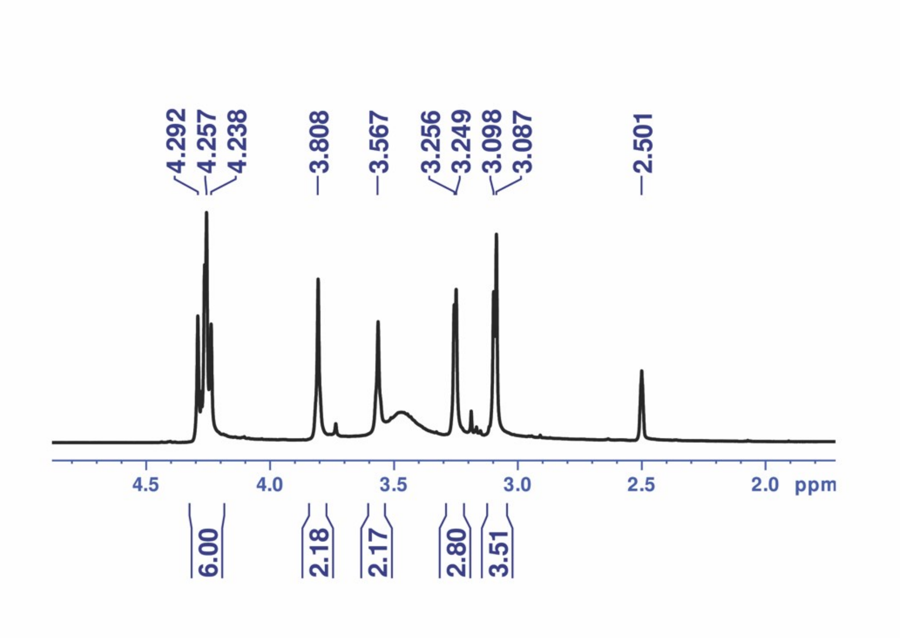

Figure S9: *^{1}H-NMR of **2** recorded in DMSO-d_6.*

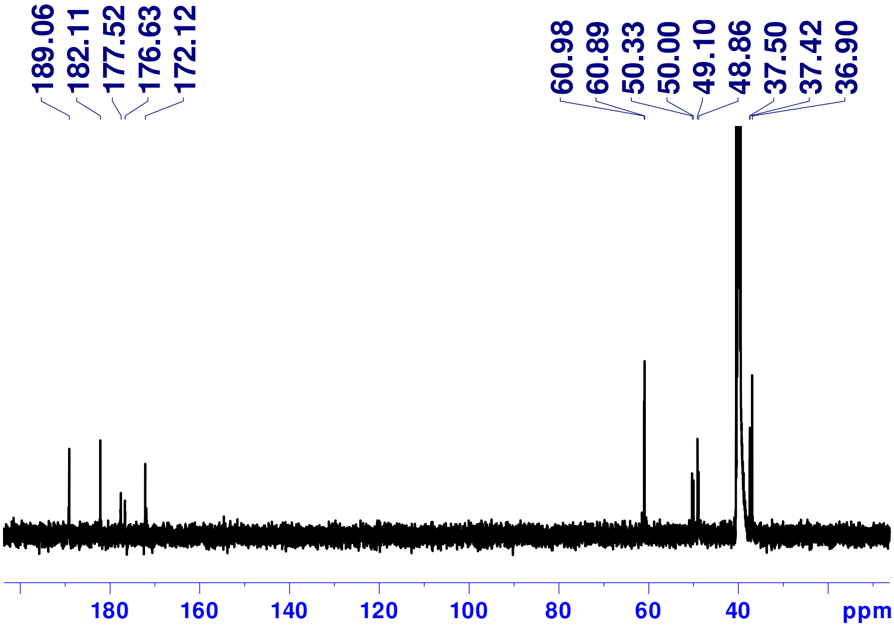

Figure S10: *^{13}C-NMR of **2** recorded in DMSO-d_6.*

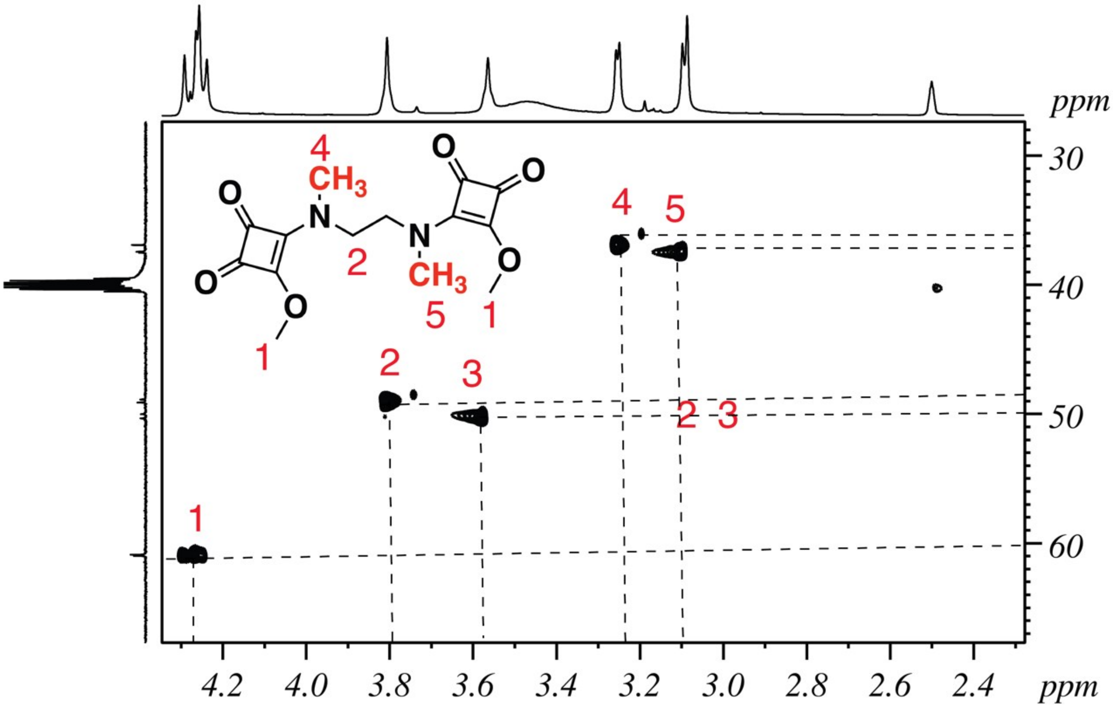

Figure S11: *^{1}H-^{13}C HSQC of **2** recorded in DMSO-d$_6$.*

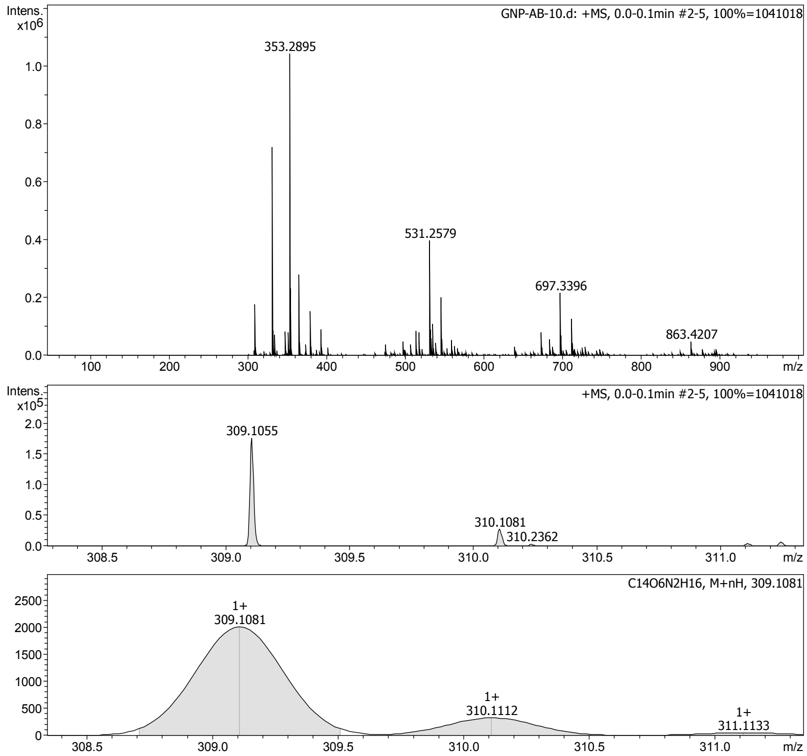

Figure S12: *Mass spectra of **2**.*

Sq-1,4-dimer (3):

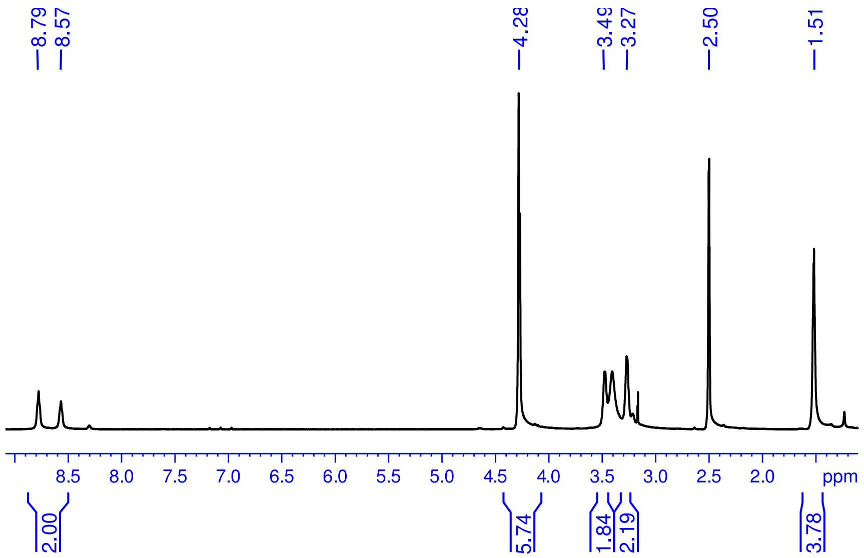

Figure S13: *^{1}H-NMR of **3** recorded in DMSO-d_6*

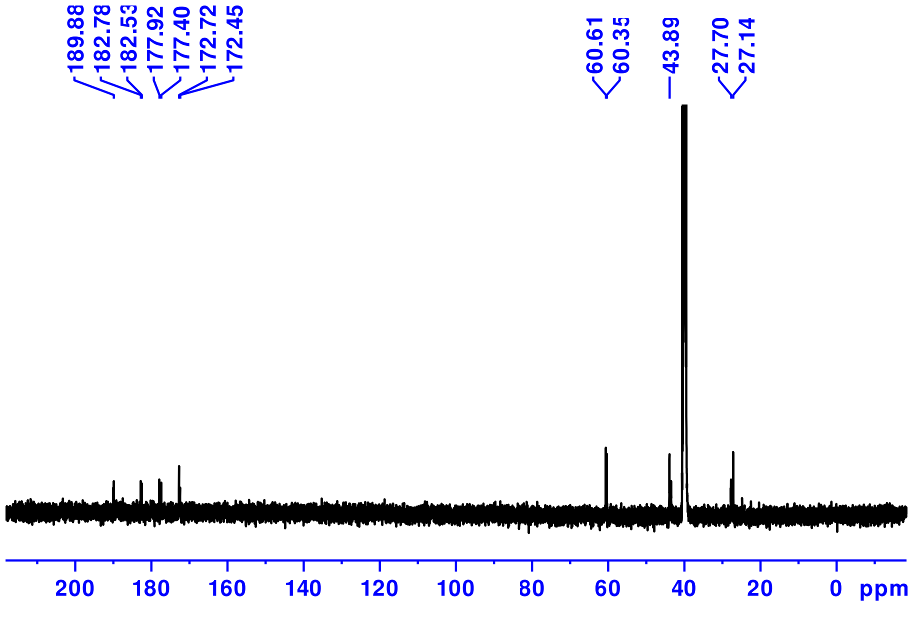

Figure S14: *^{13}C-NMR of **3** recorded in DMSO-d_6*

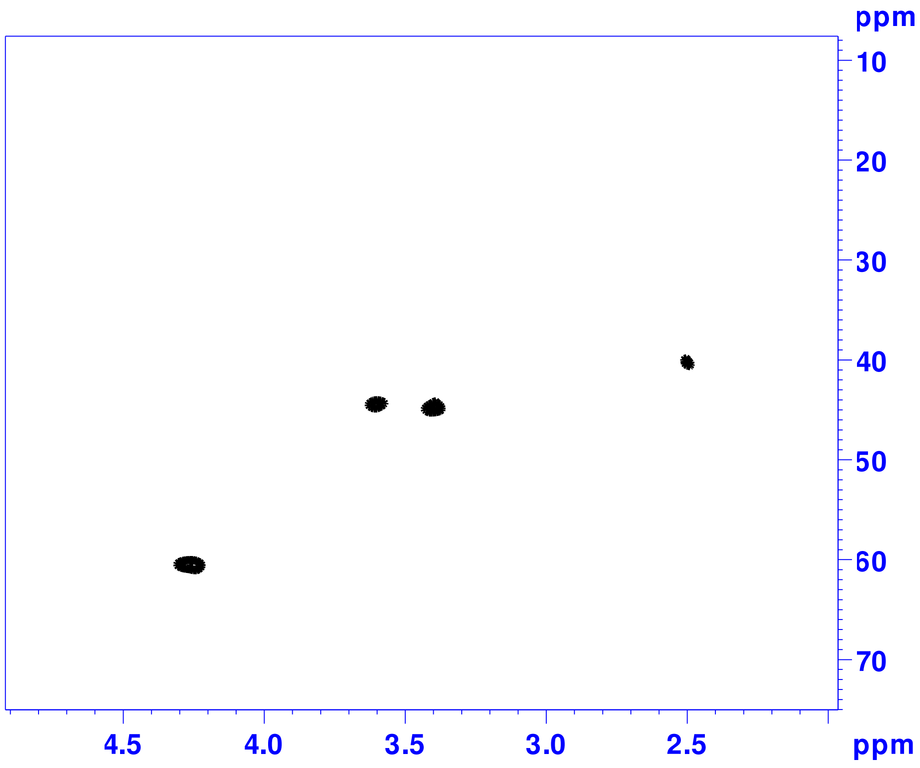

***Figure S15:** ^{1}H-^{13}C HSQC NMR of **3** recorded in DMSO-d$_6$.*

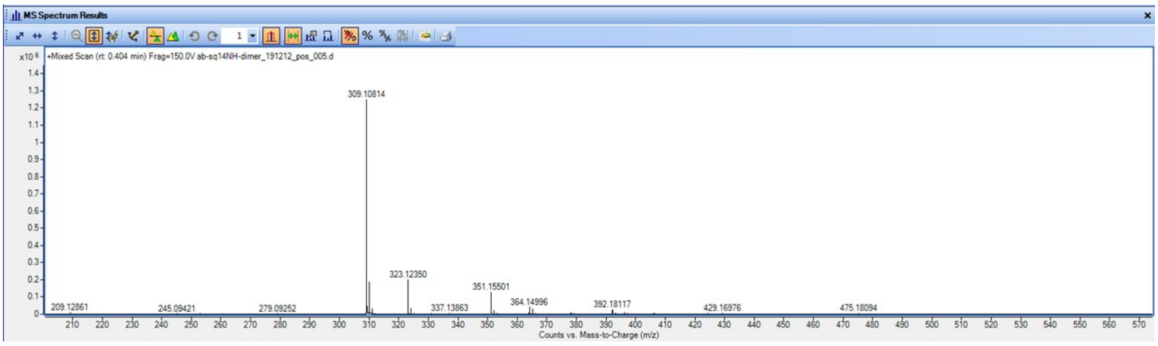

Figure S16:** Mass spectra of **3.

Sq-1,3-N-methyl-dimer (4):

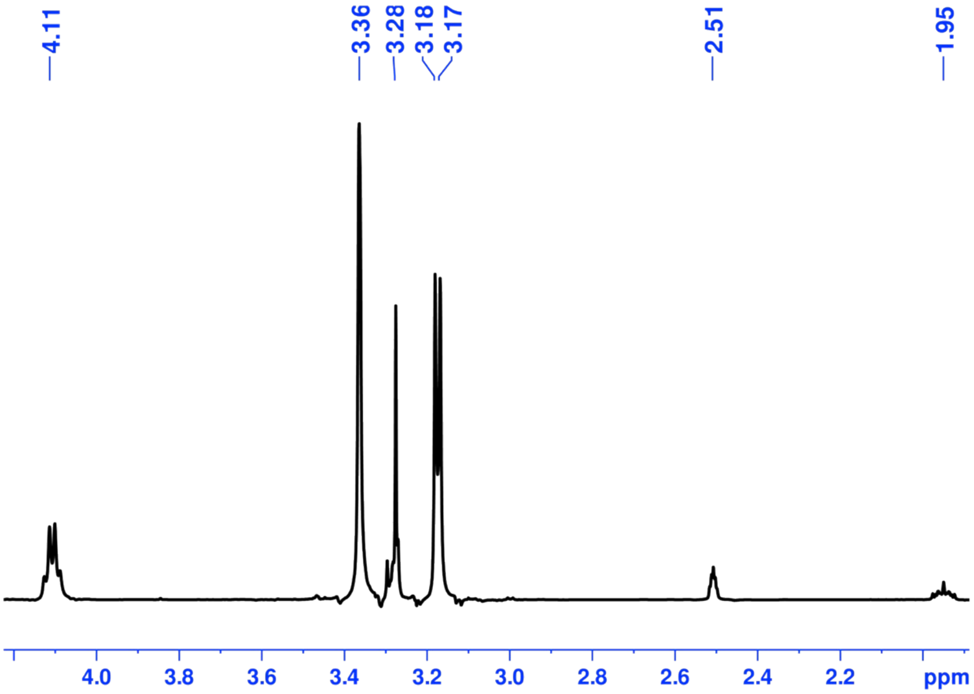

Figure S17: *^{1}H-NMR of **2** recorded in DMSO-d_6*

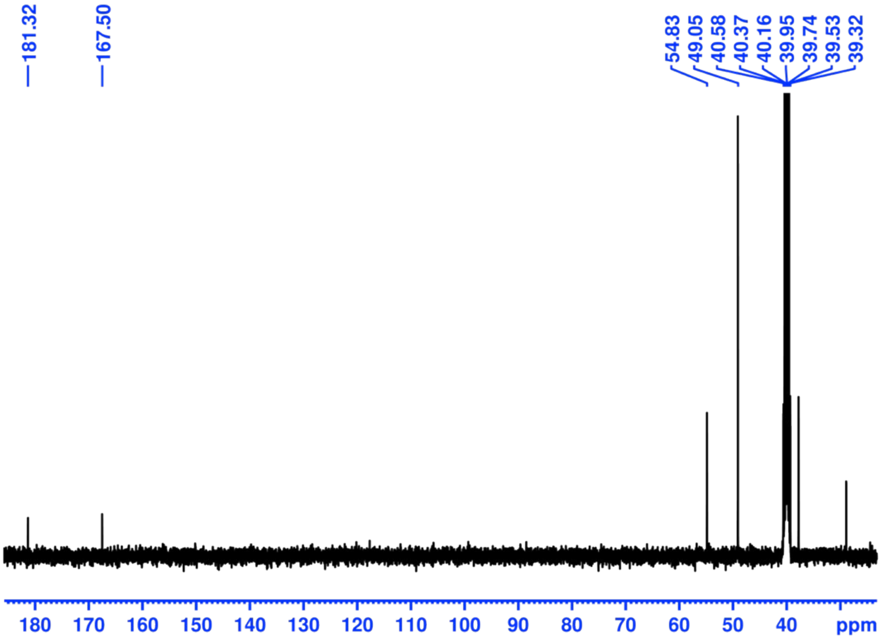

Figure S18: *^{13}C-NMR of **4** recorded in DMSO-d_6*

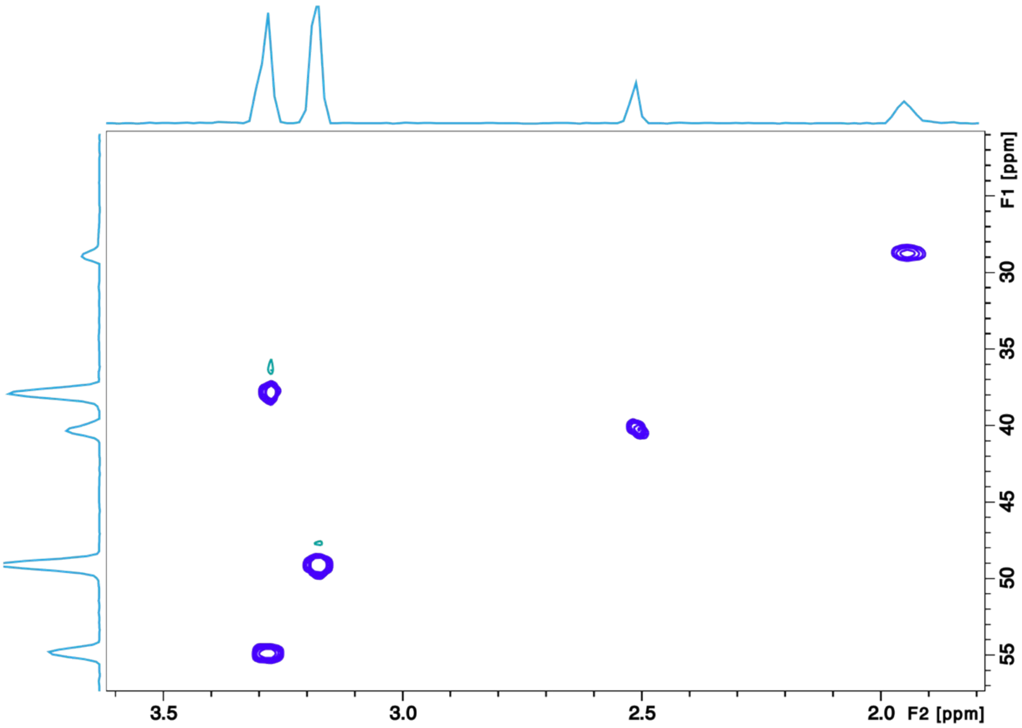

Figure S19: *^{1}H-^{13}C- HSQC NMR of **4** recorded in DMSO-d$_{6}$.*