# Pyrene-based organic dyes with thiophene containing π-linkers for dye-sensitized solar cells: optical, electrochemical and theoretical investigations

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# Electronic Supplementary Information

## Content

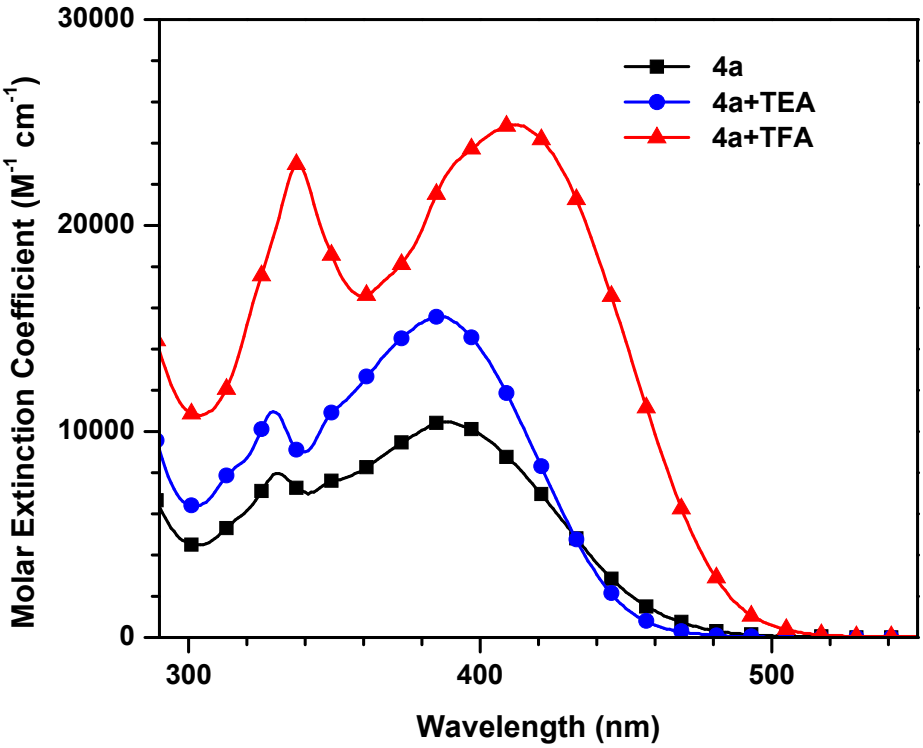


**Fig. S1.** Absorption spectra of the dye **4a** recorded in THF solutions before and after the addition of TEA or TFA.

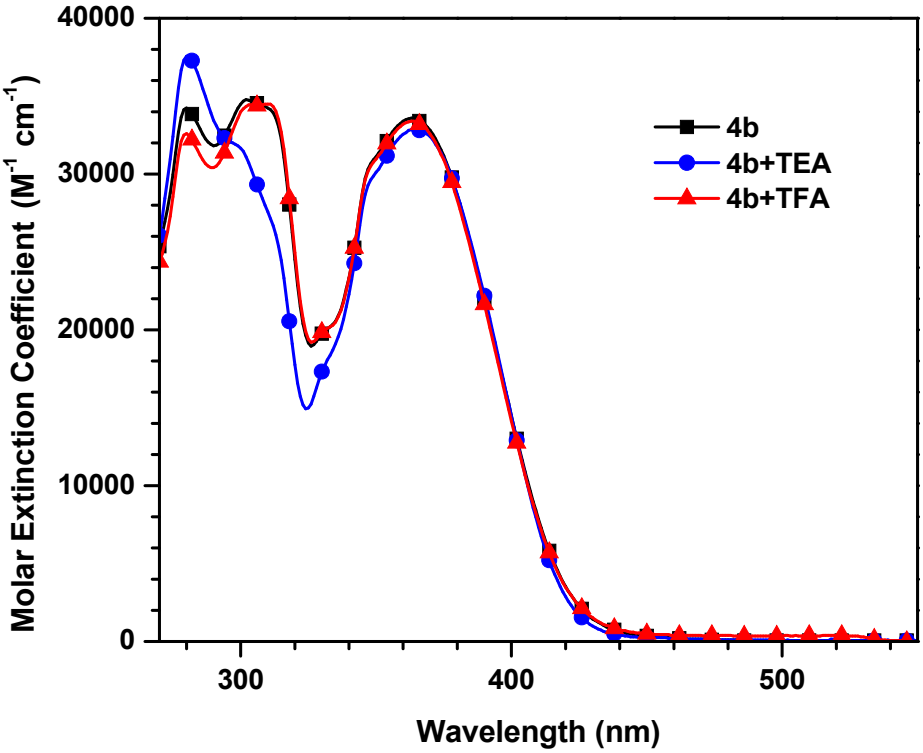


**Fig. S2.** Absorption spectra of the dye **4b** recorded in THF solutions before and after the addition of TEA or TFA.

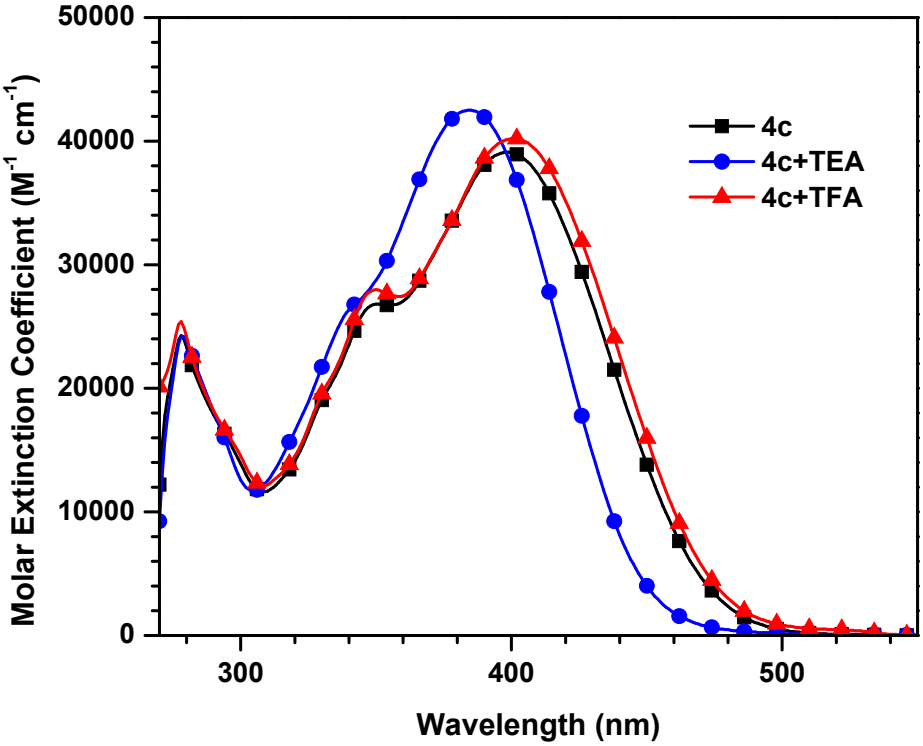


**Fig. S3.** Absorption spectra of the dye **4c** recorded in THF solutions before and after the addition of TEA or TFA.

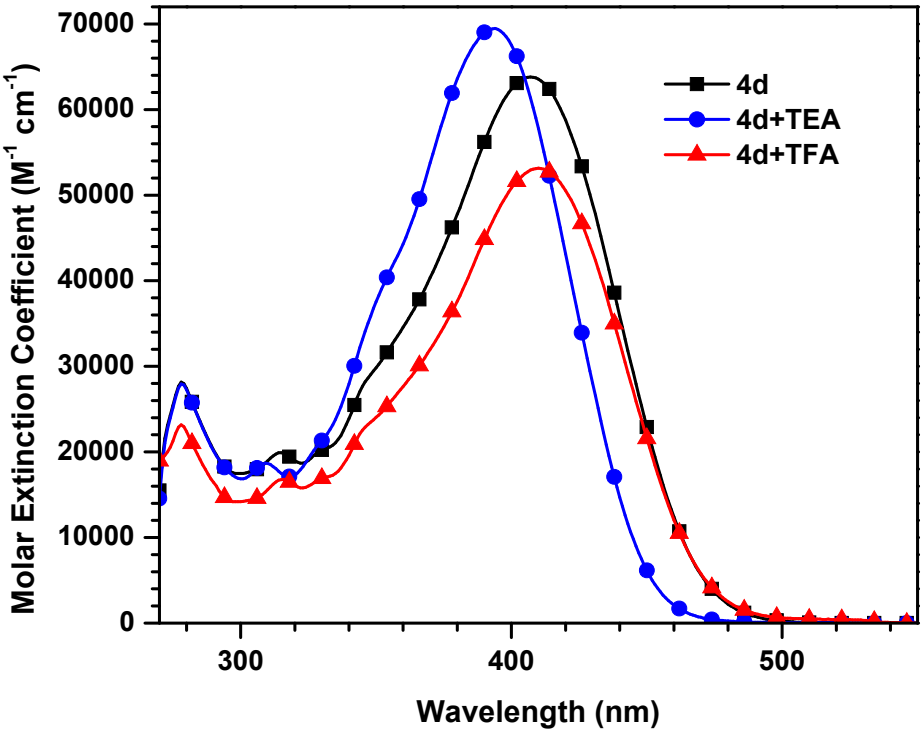


**Fig. S4.** Absorption spectra of the dye **4d** recorded in THF solutions before and after the addition of TEA or TFA.

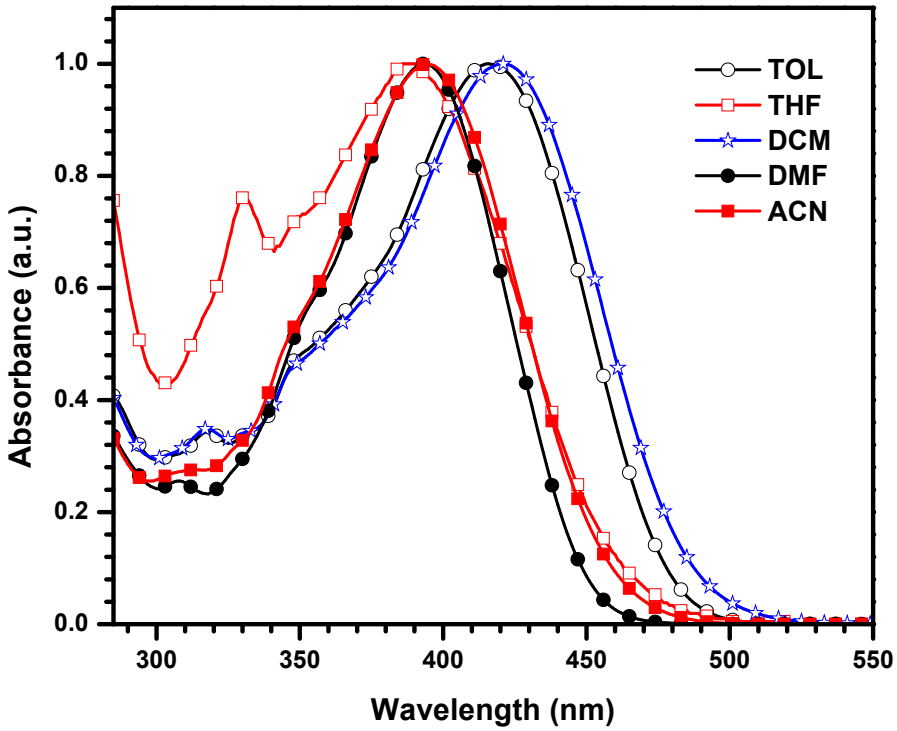


**Fig. S5** Absorption spectra of the dye **4a** recorded in different solvents.

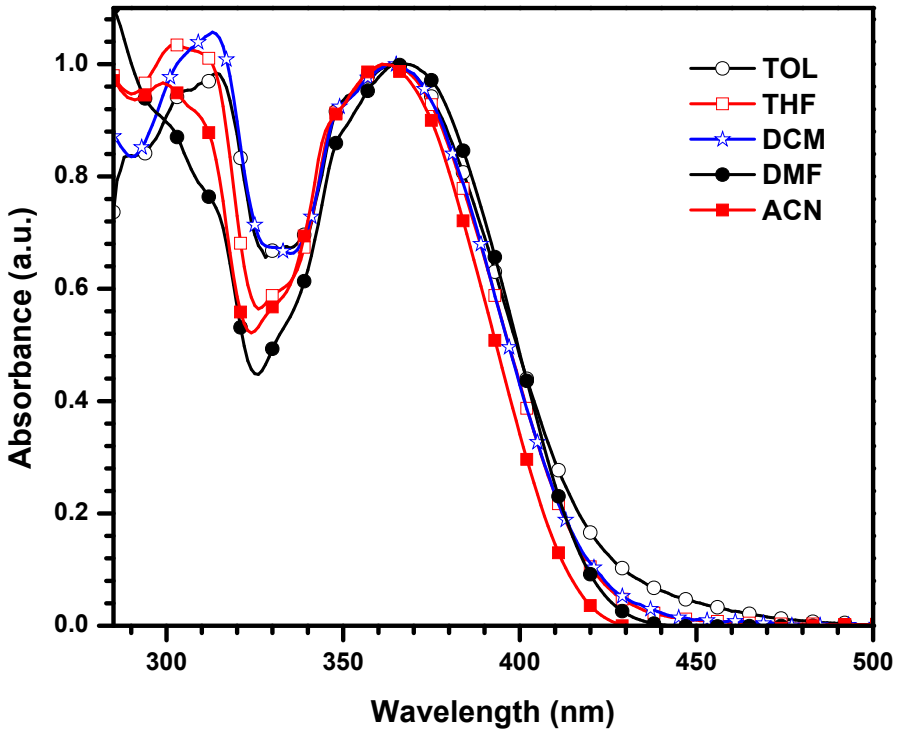


**Fig. S6** Absorption spectra of the dye **4b** recorded in different solvents.

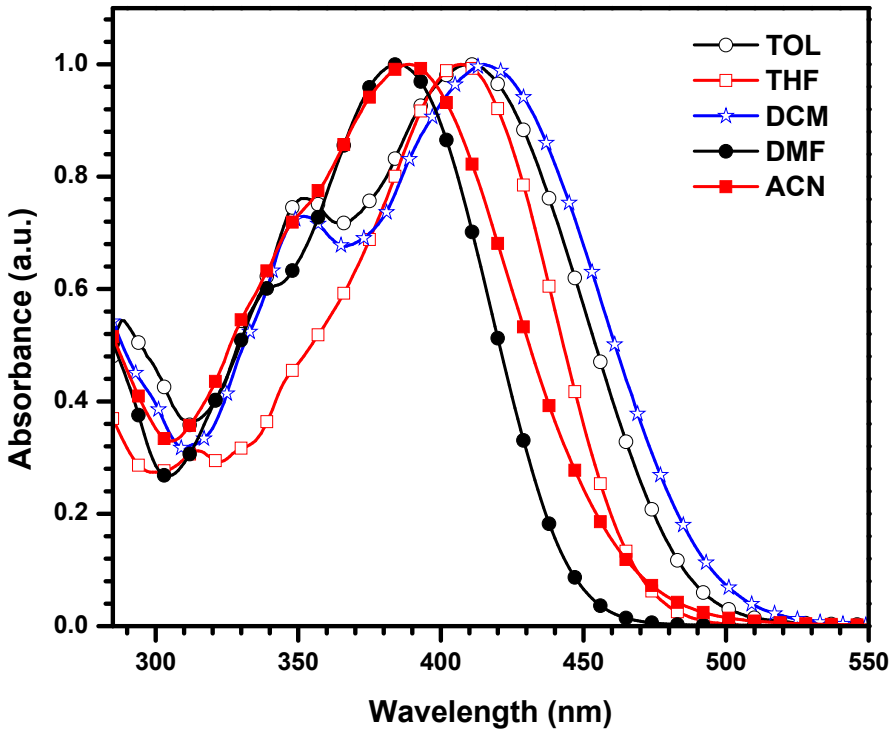


**Fig. S7** Absorption spectra of the dye **4d** recorded in different solvents.

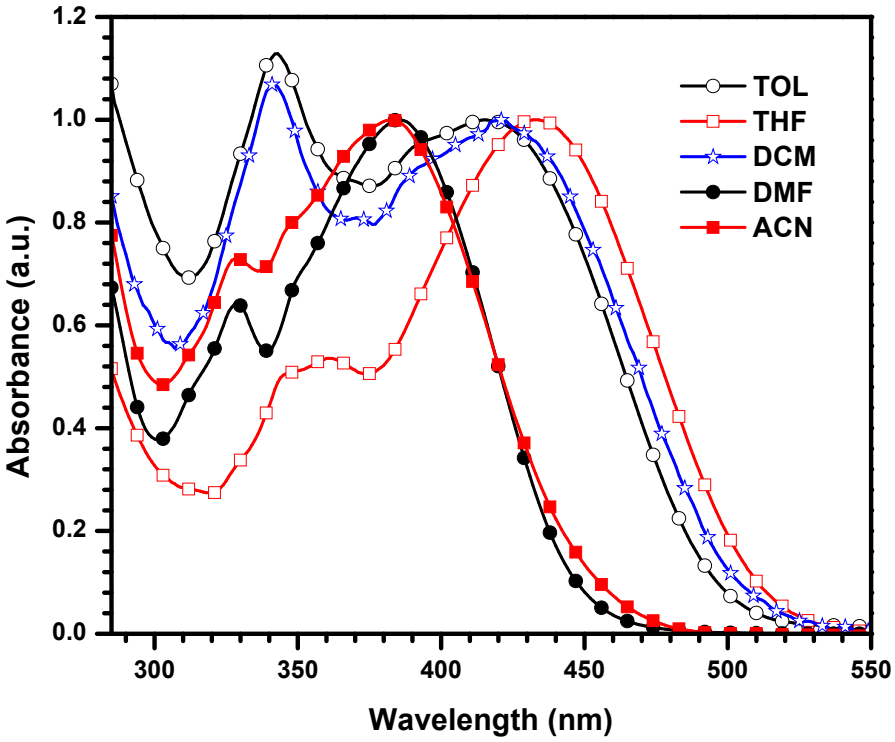


**Fig. S8** Absorption spectra of the dye **4e** recorded in different solvents.

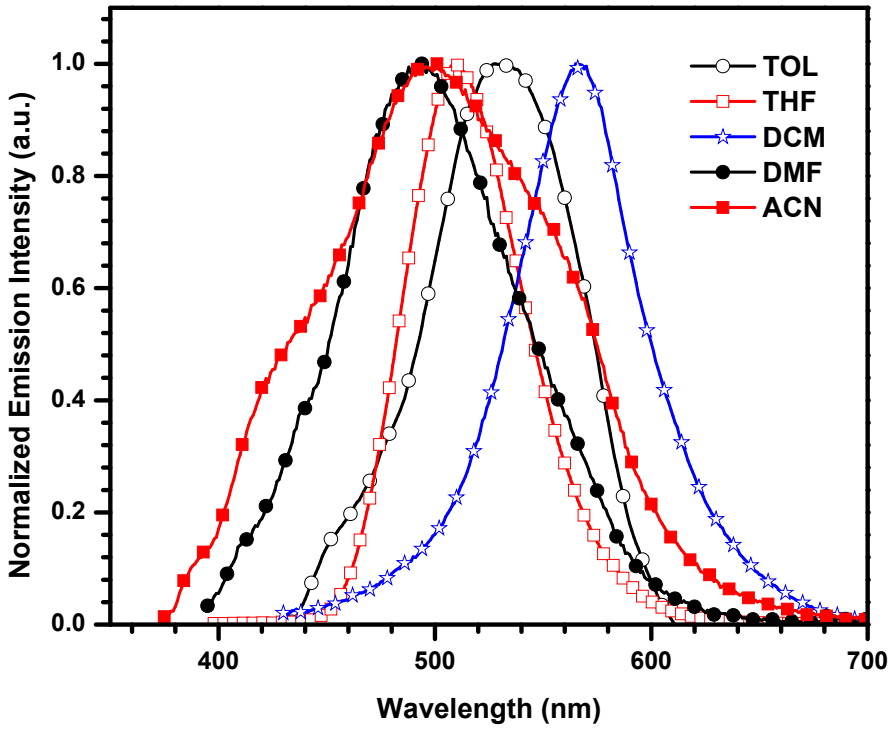


**Fig. S9** Emission spectra of **4a** recorded in different solvents.

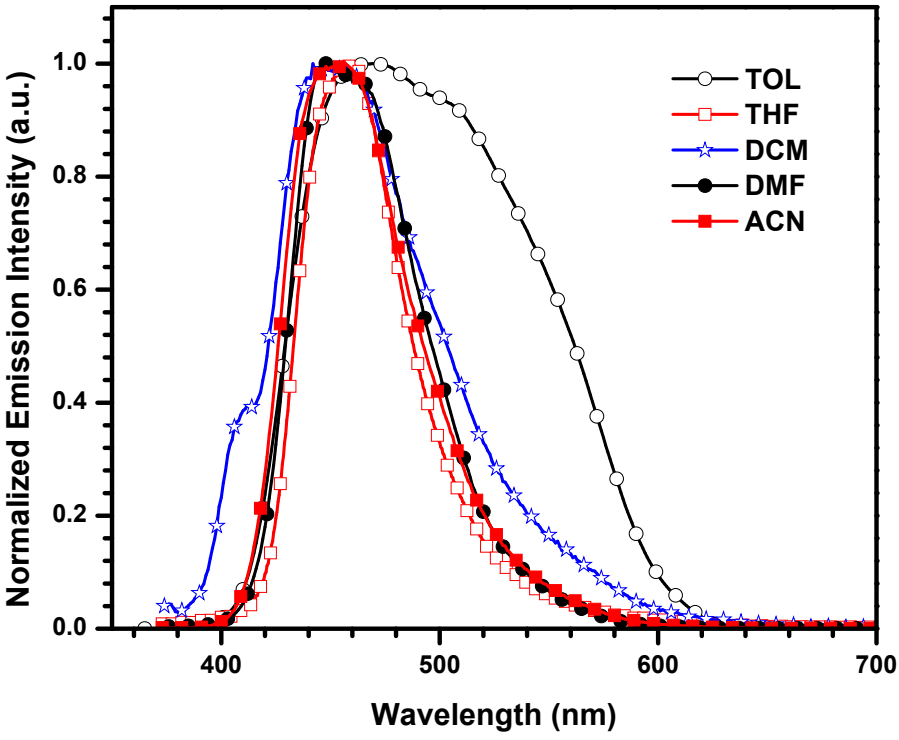


**Fig. S10** Emission spectra of **4b** recorded in different solvents.

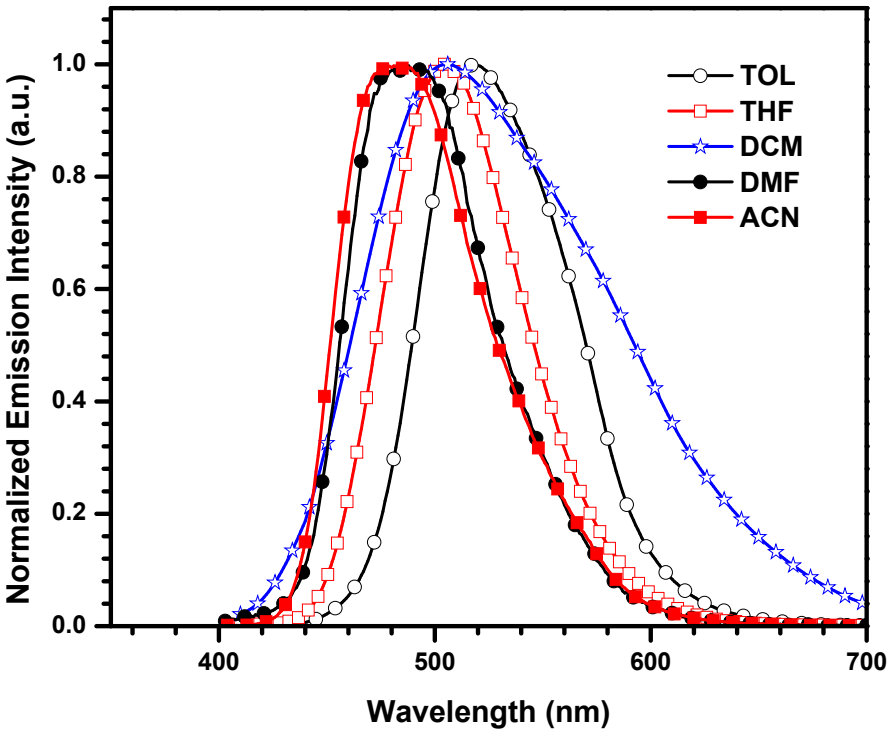


**Fig. S11** Emission spectra of **4d** recorded in different solvents.

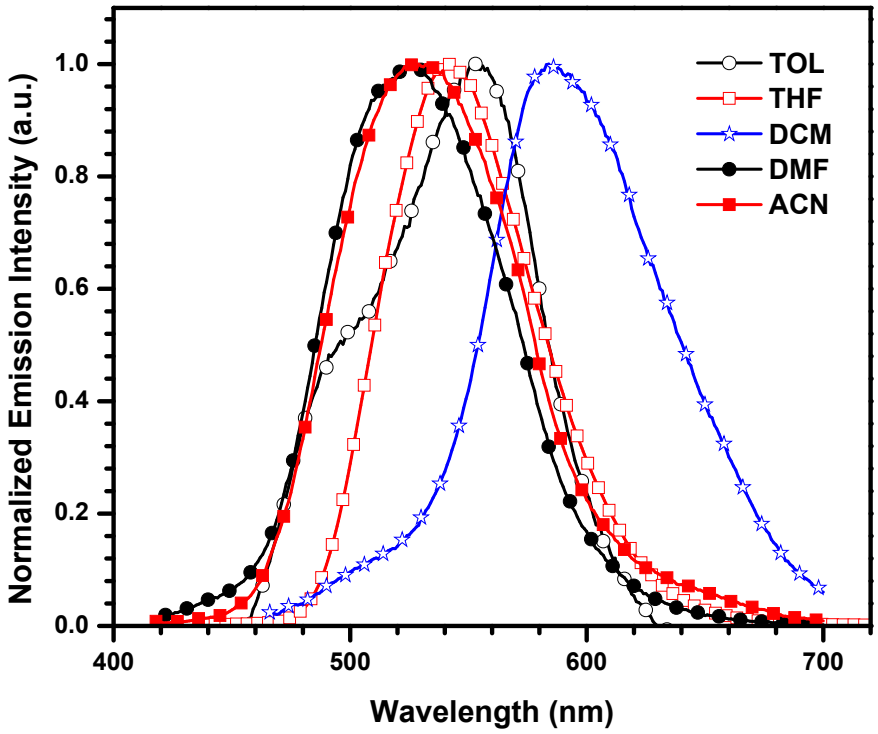


**Fig. S12** Emission spectra of **4e** recorded in different solvents.

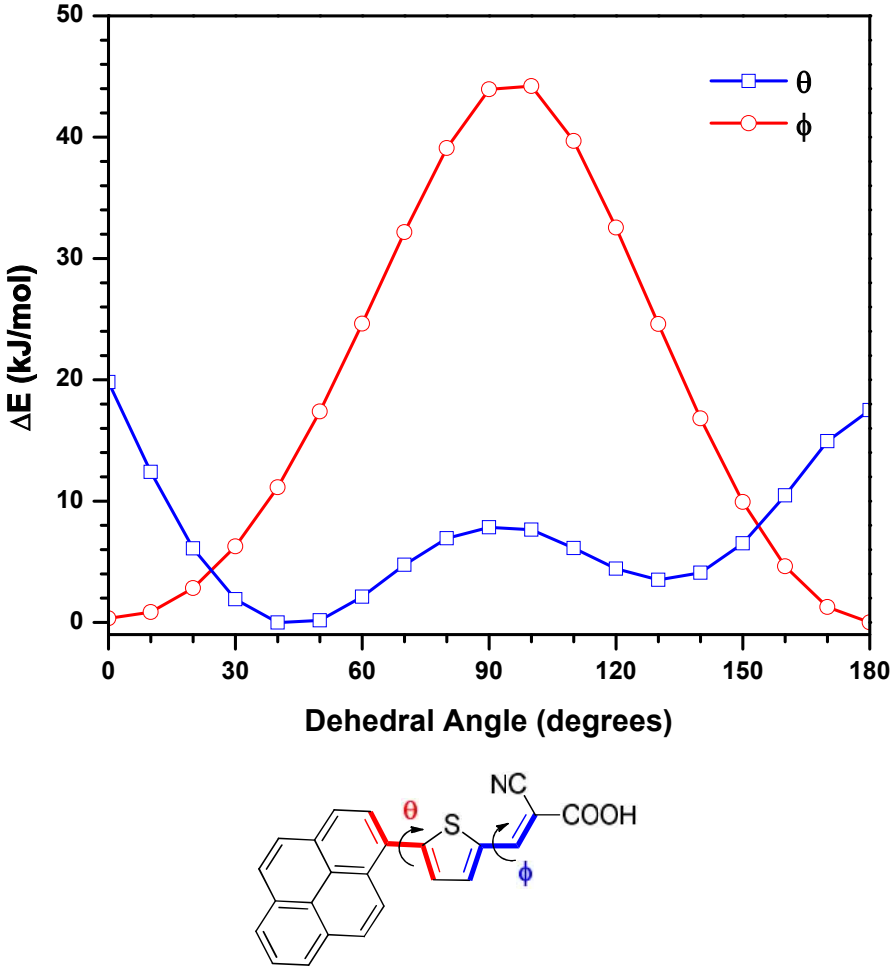


**Fig. S13** Potential energy surface scan as a function of dihedral angle defining the rotation between the key units in **4a**.

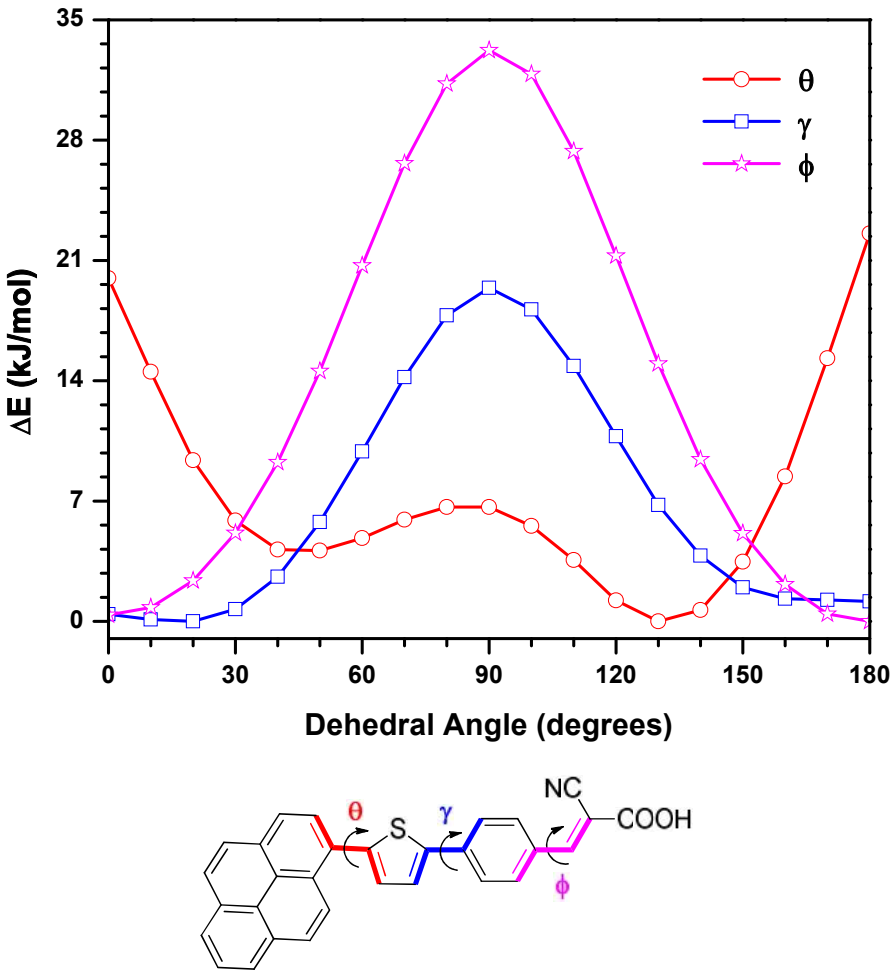


**Fig. S14** Potential energy surface scan as a function of dihedral angle defining the rotation between the key units in **4c**.

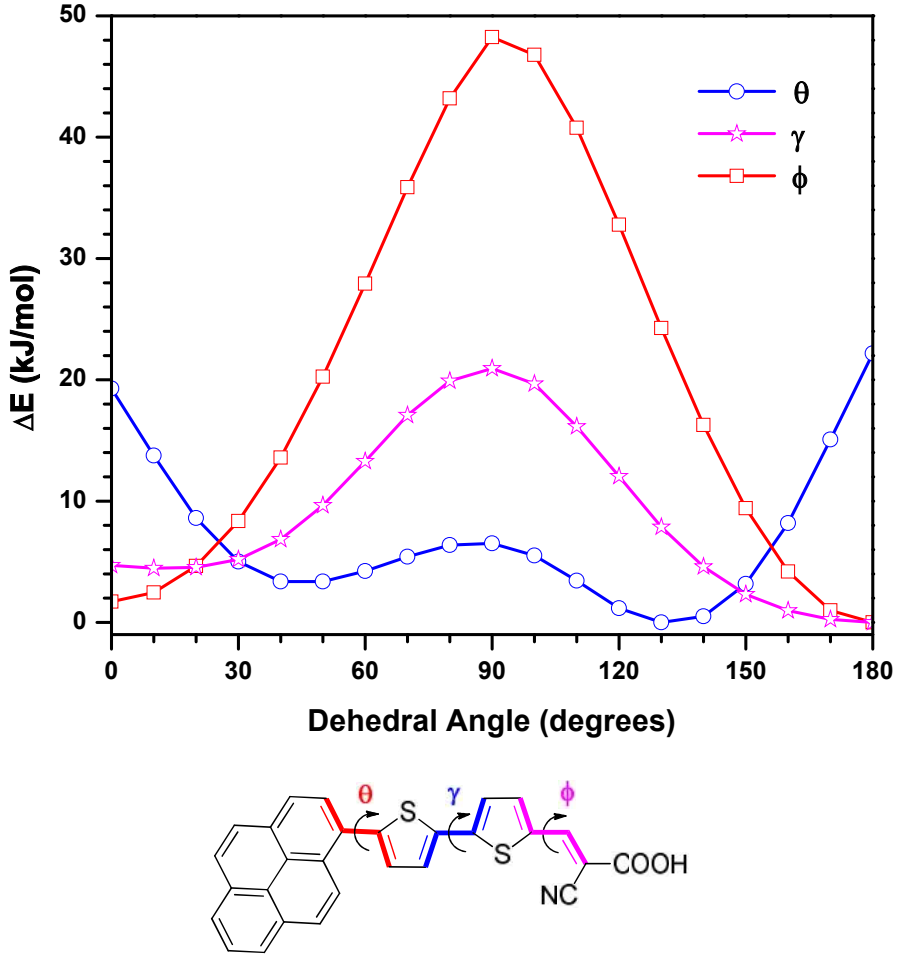


**Fig. S15** Potential energy surface scan as a function of dihedral angle defining the rotation between the key units in **4e**.

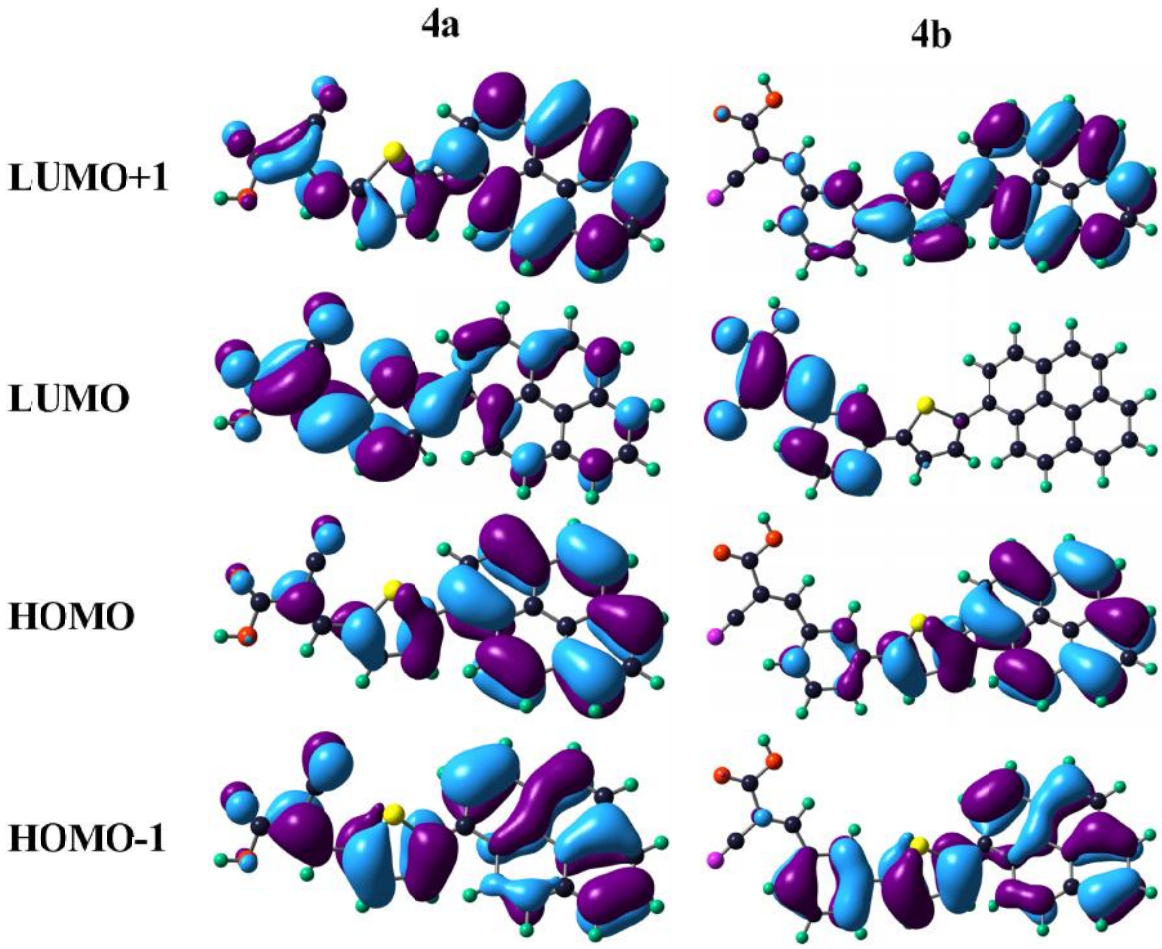


**Fig. S16** Electronic distributions in the frontier molecular orbitals of the dyes **4a** and **4b**.

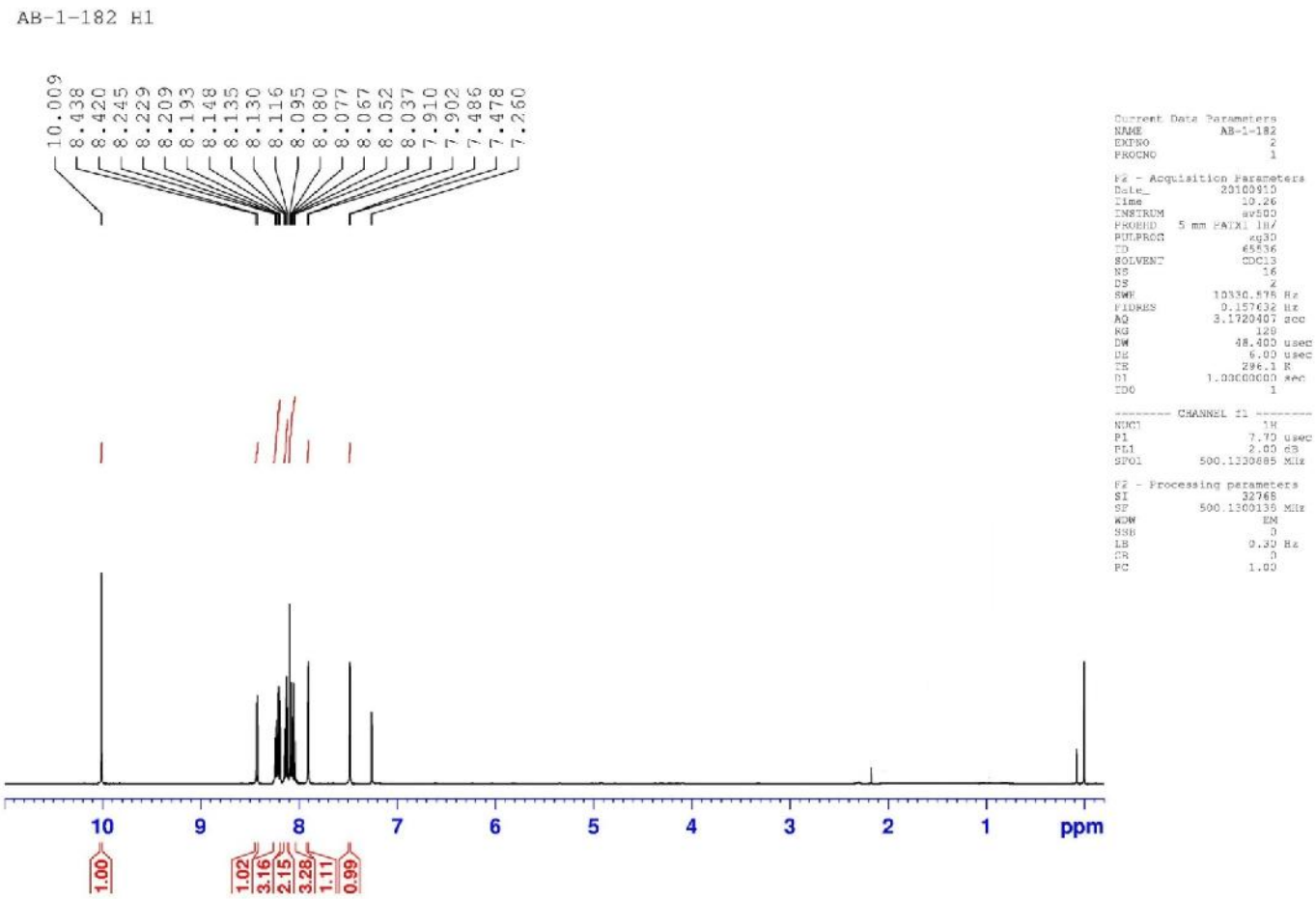


**Fig. S17** $^{1}$H NMR spectra of **3a** recorded in $CDCl_3$.

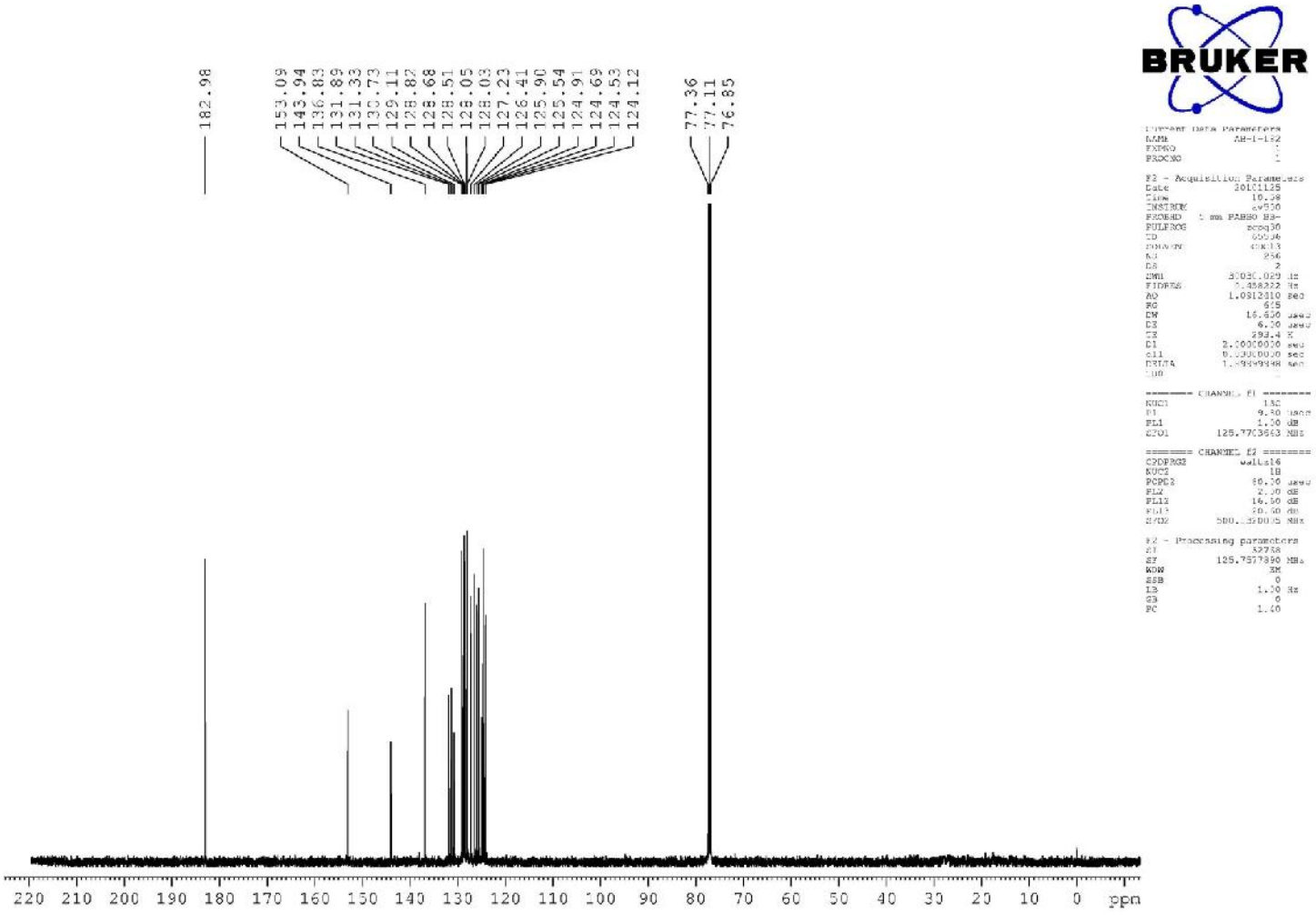


**Fig. S18** $^{13}C$ NMR spectra of 3a recorded in $CDCl_3$.

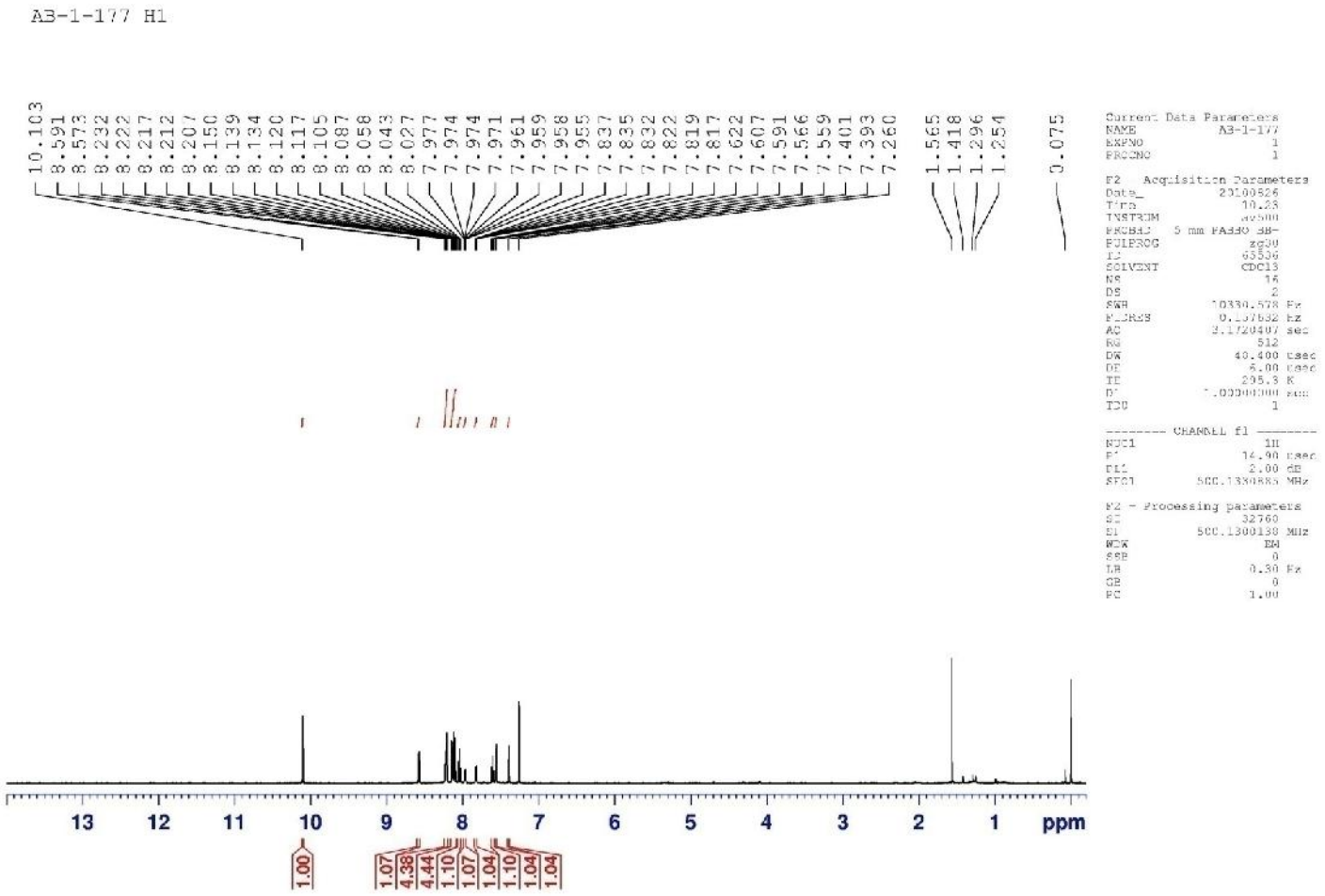


**Fig. S19** $^{1}$H NMR spectra of **3b** recorded in $CDCl_3$.

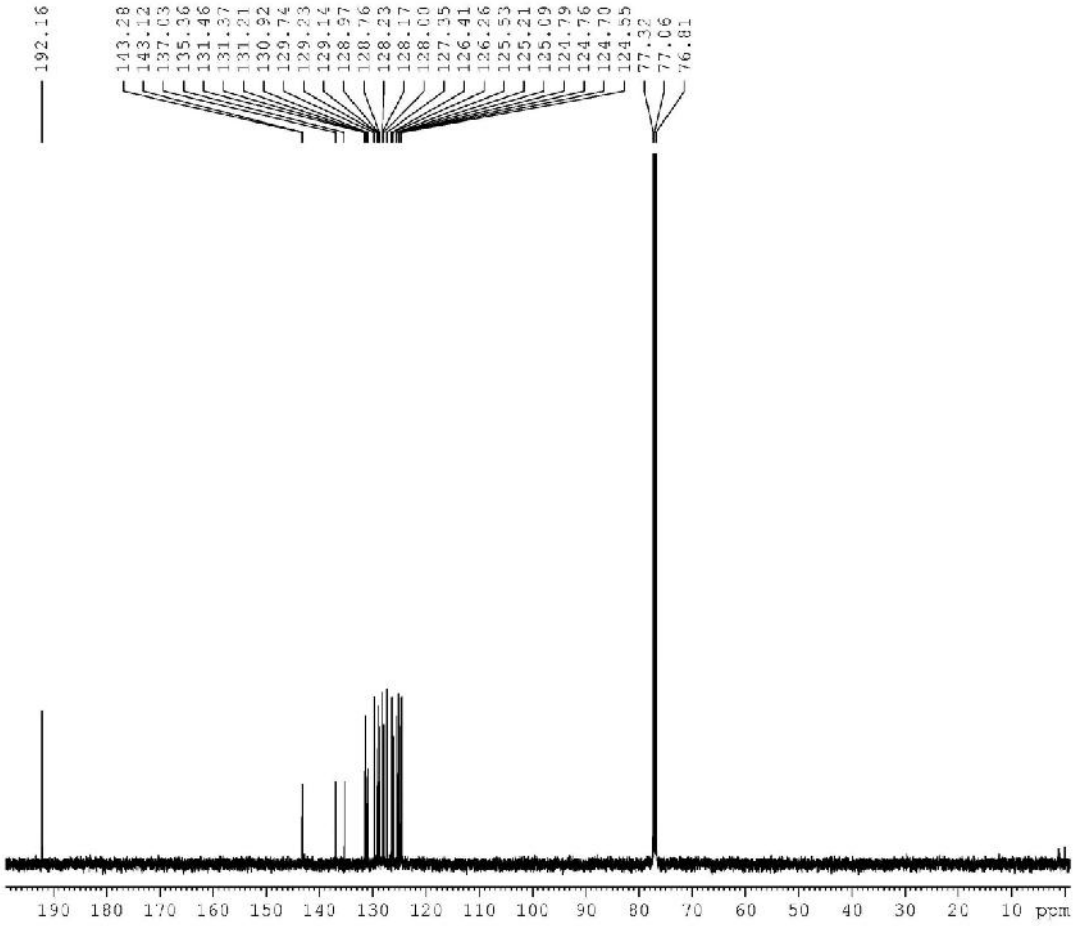



**Fig. S20** $^{13}$C NMR spectra of **3b** recorded in $CDCl_3$.

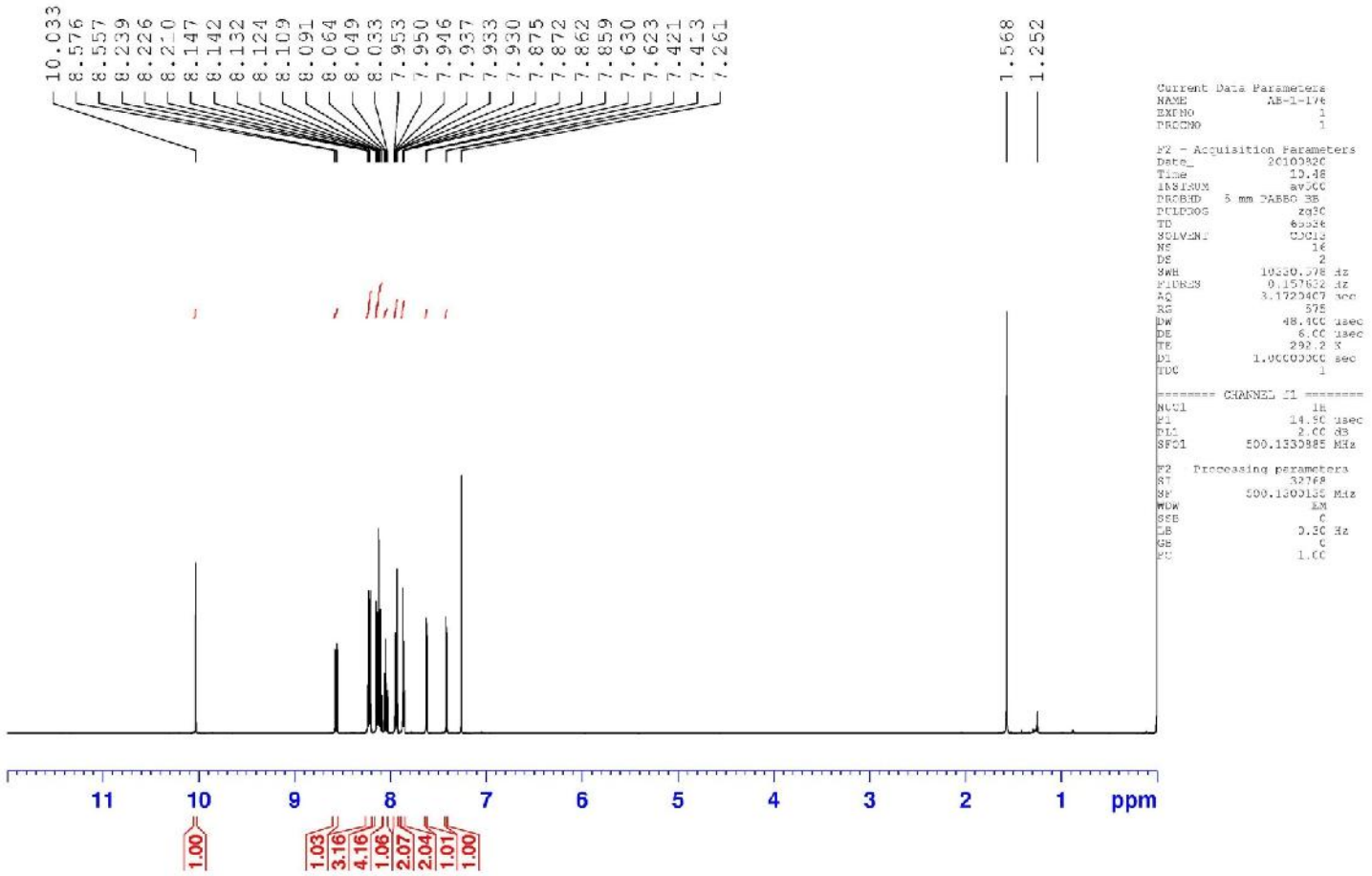


**Fig. S21** $^{1}$H NMR spectra of **3c** recorded in $CDCl_3$.

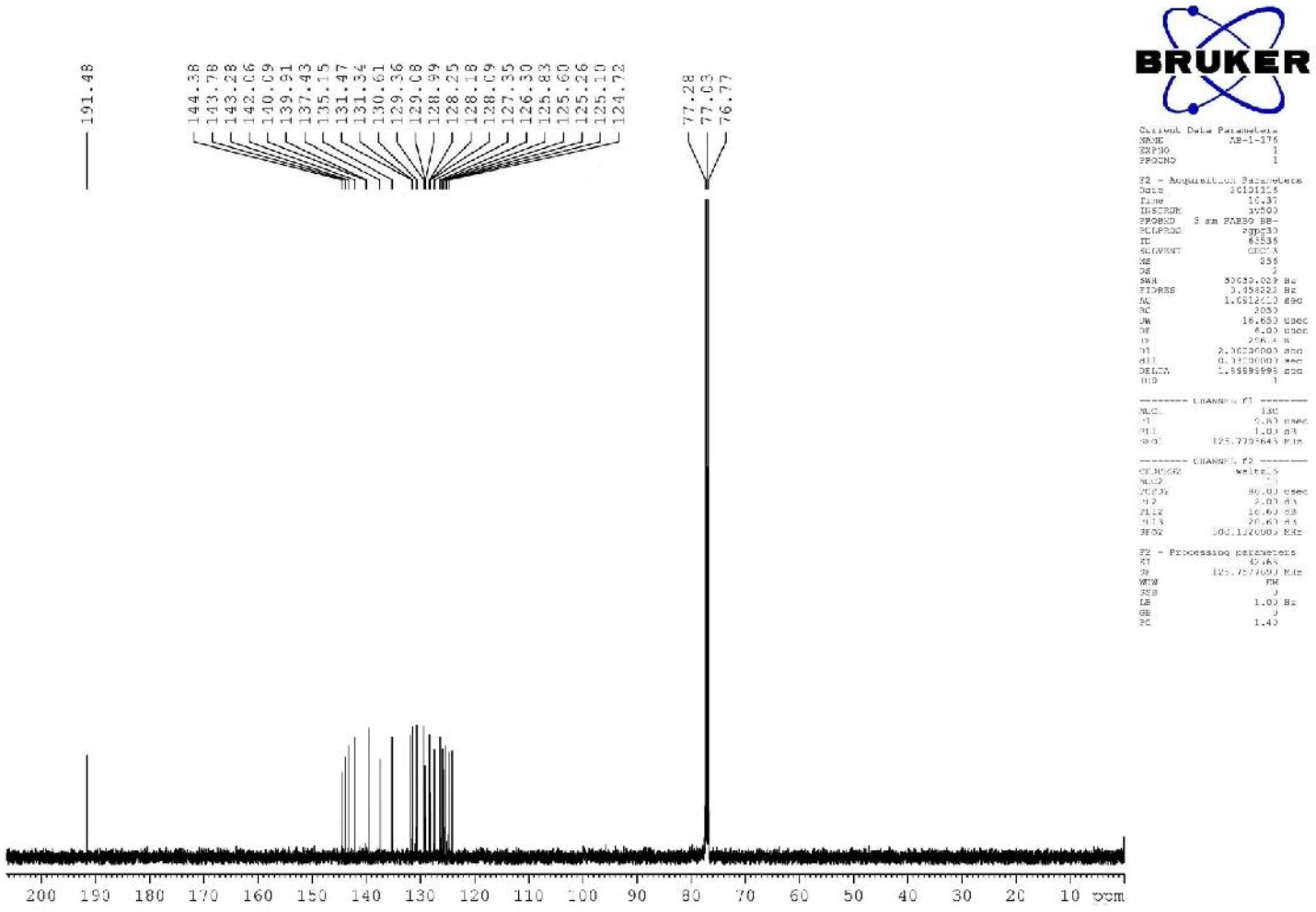


**Fig. S22** $^{13}C$ NMR spectra of **3c** recorded in $CDCl_3$.

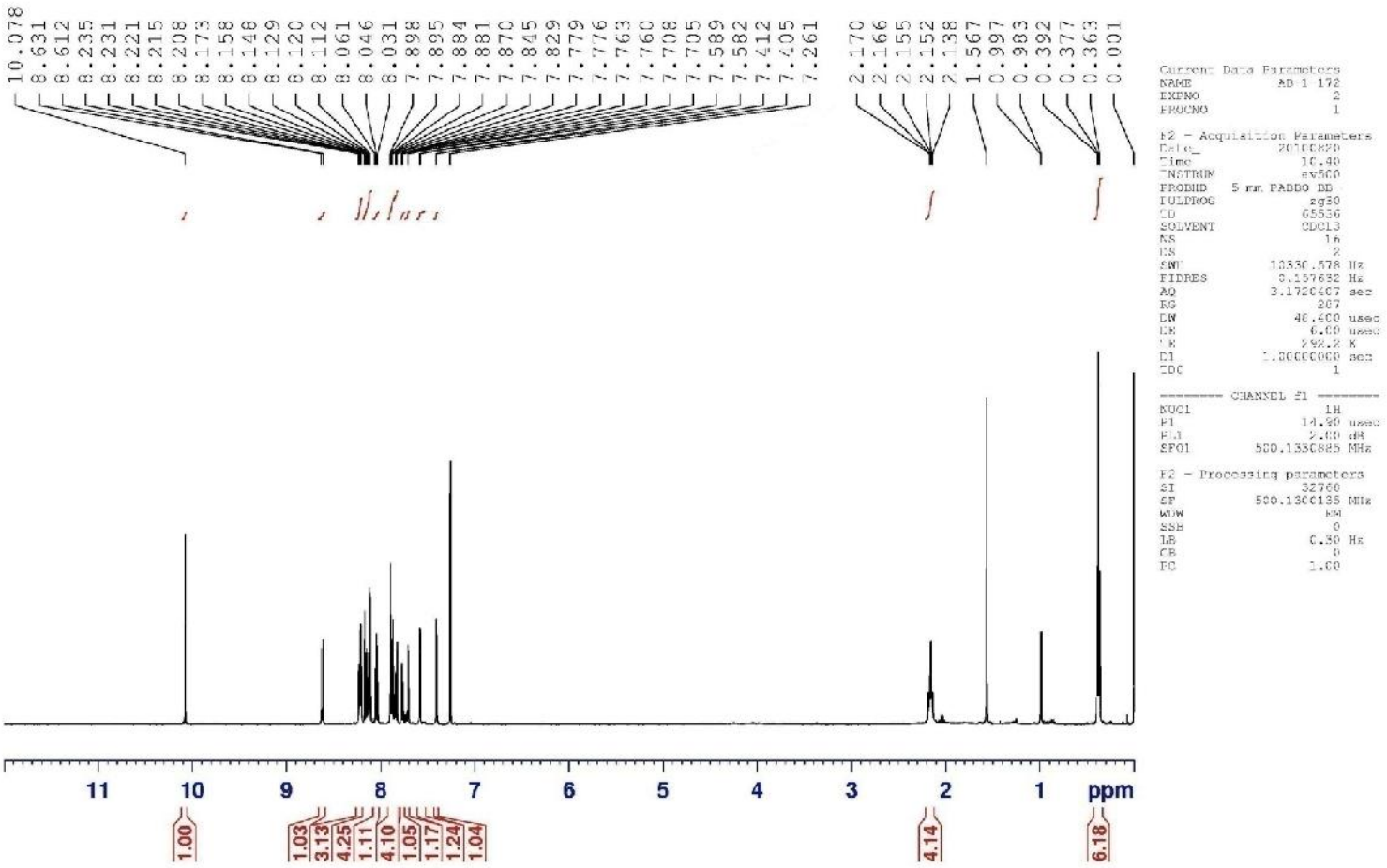


**Fig. S23** $^{1}$H NMR spectra of **3d** recorded in $CDCl_3$.

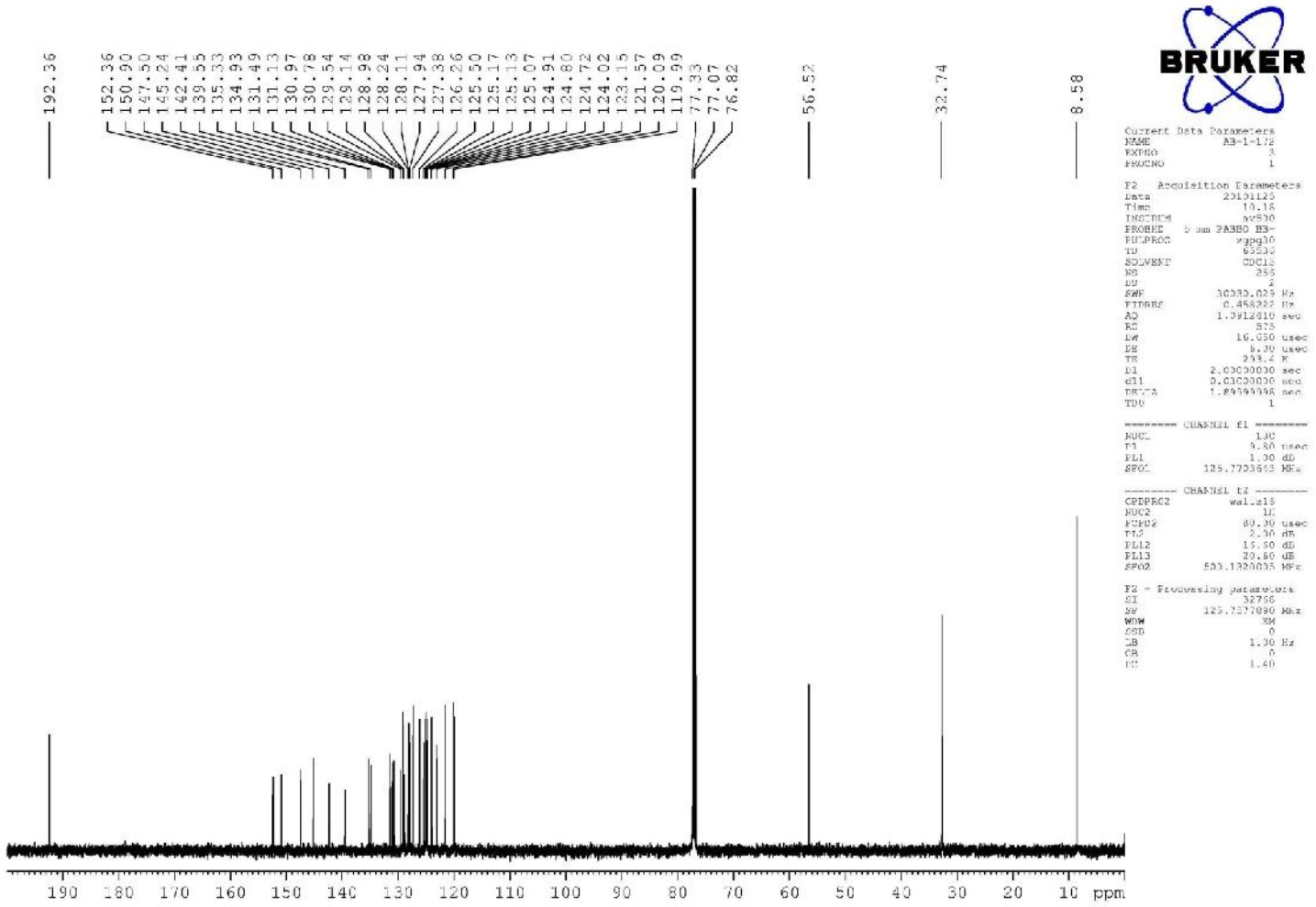


**Fig. S24** $^{13}C$ NMR spectra of **3d** recorded in $CDCl_3$.

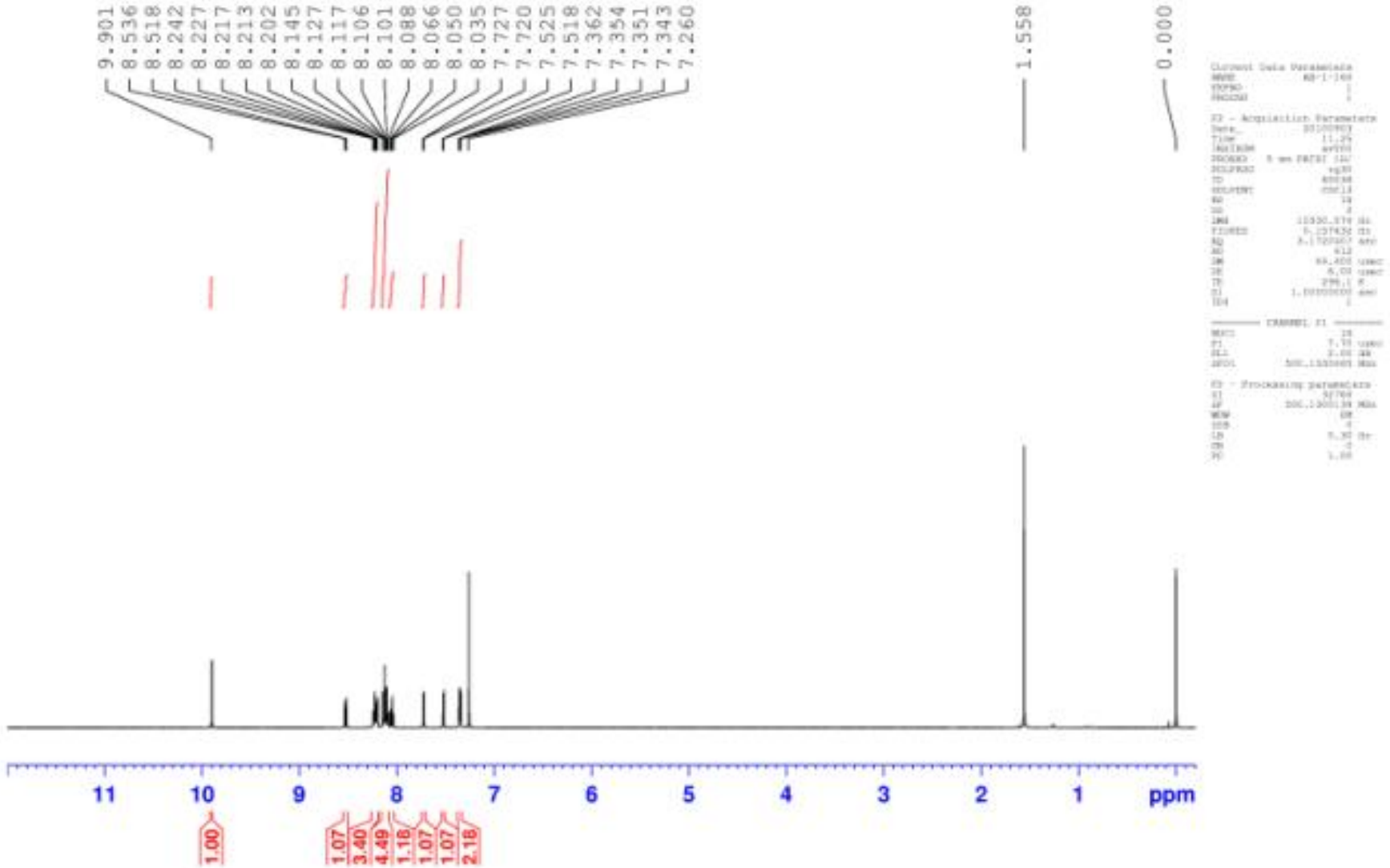


**Fig. S25** $^{1}$H NMR spectra of **3e** recorded in $CDCl_3$.

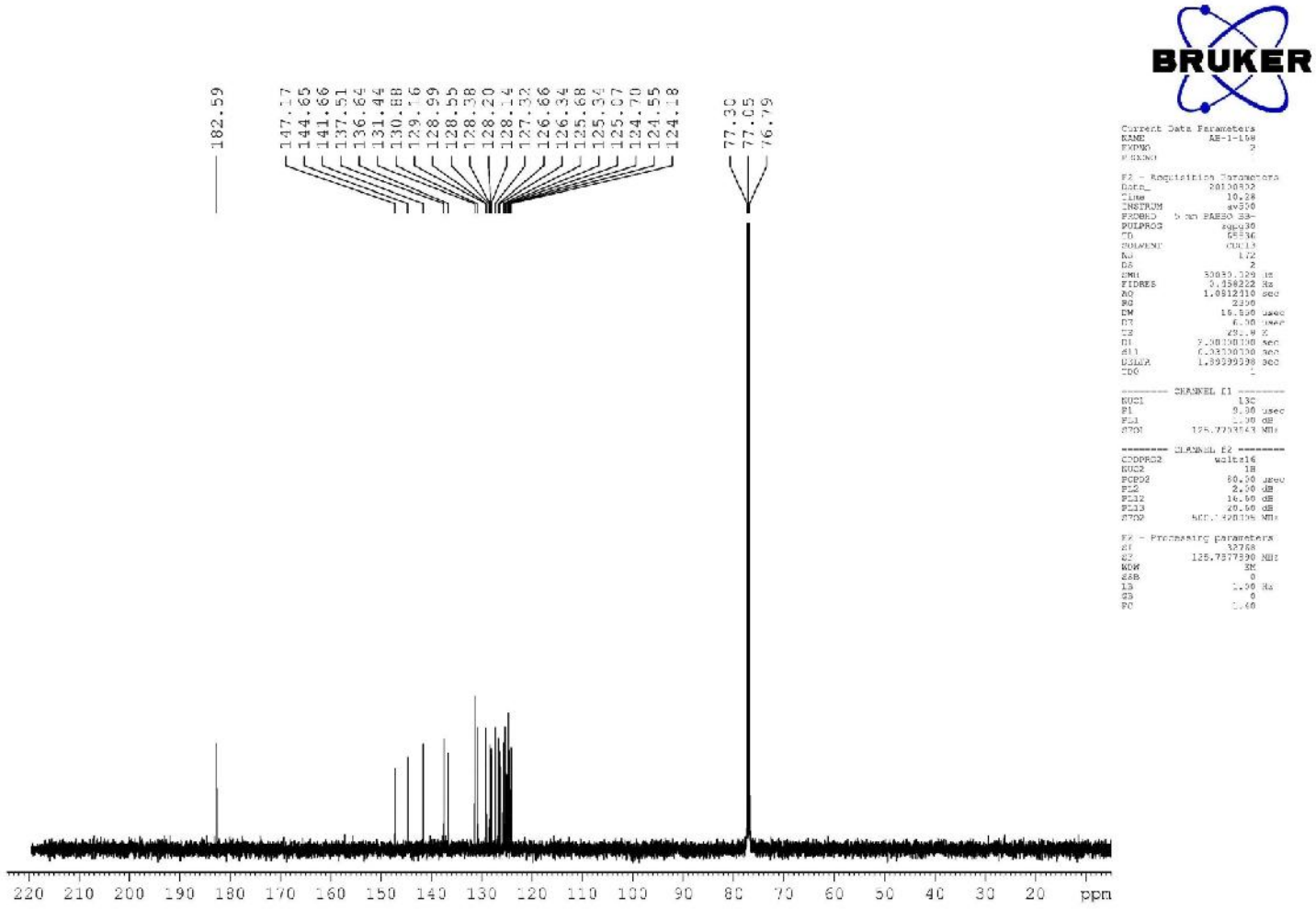


**Fig. S26** $^{13}C$ NMR spectra of **3e** recorded in $CDCl_3$.

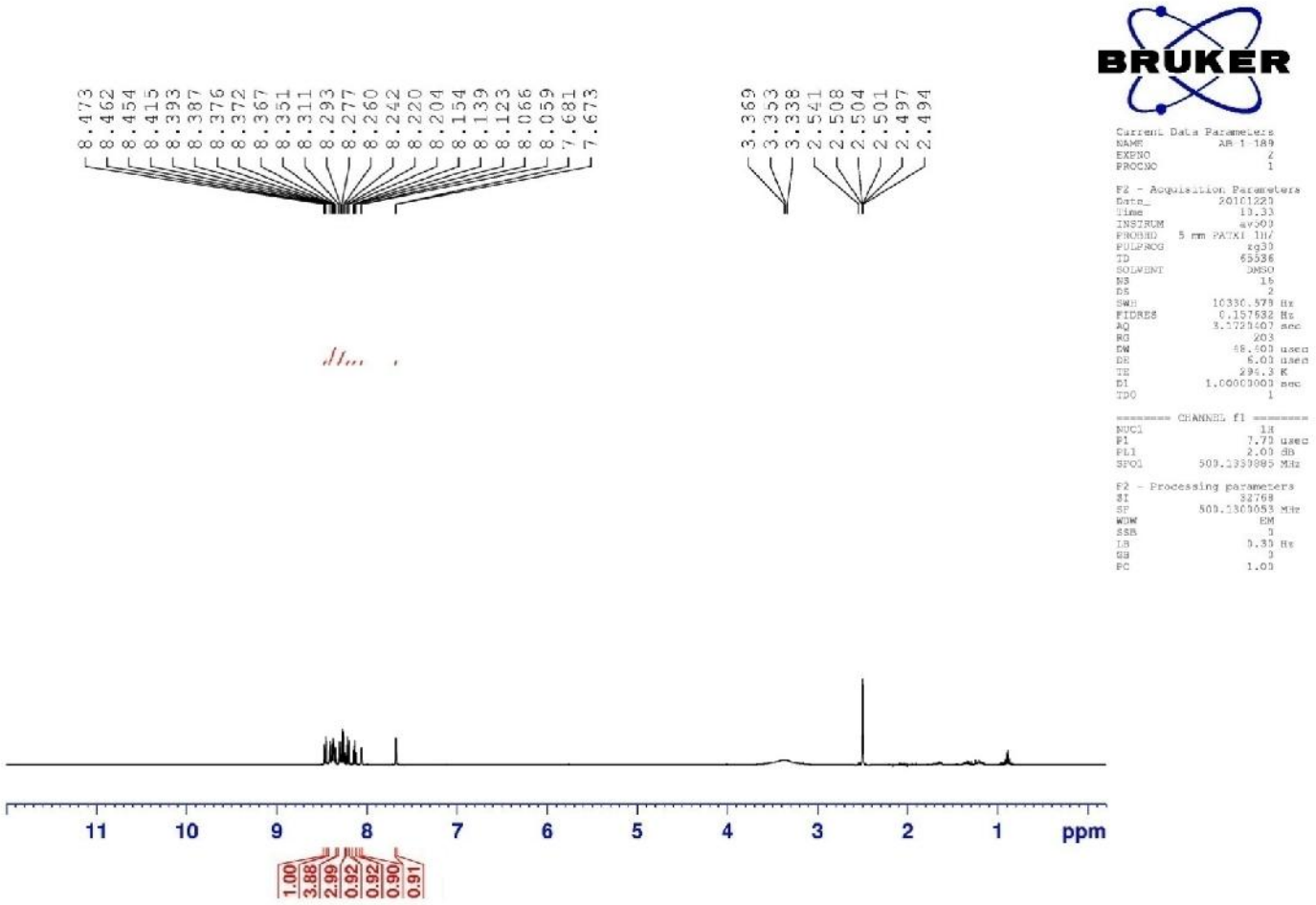


**Fig. S27** $^{1}$H NMR spectra of **4a** recorded in DMSO-$d_6$.

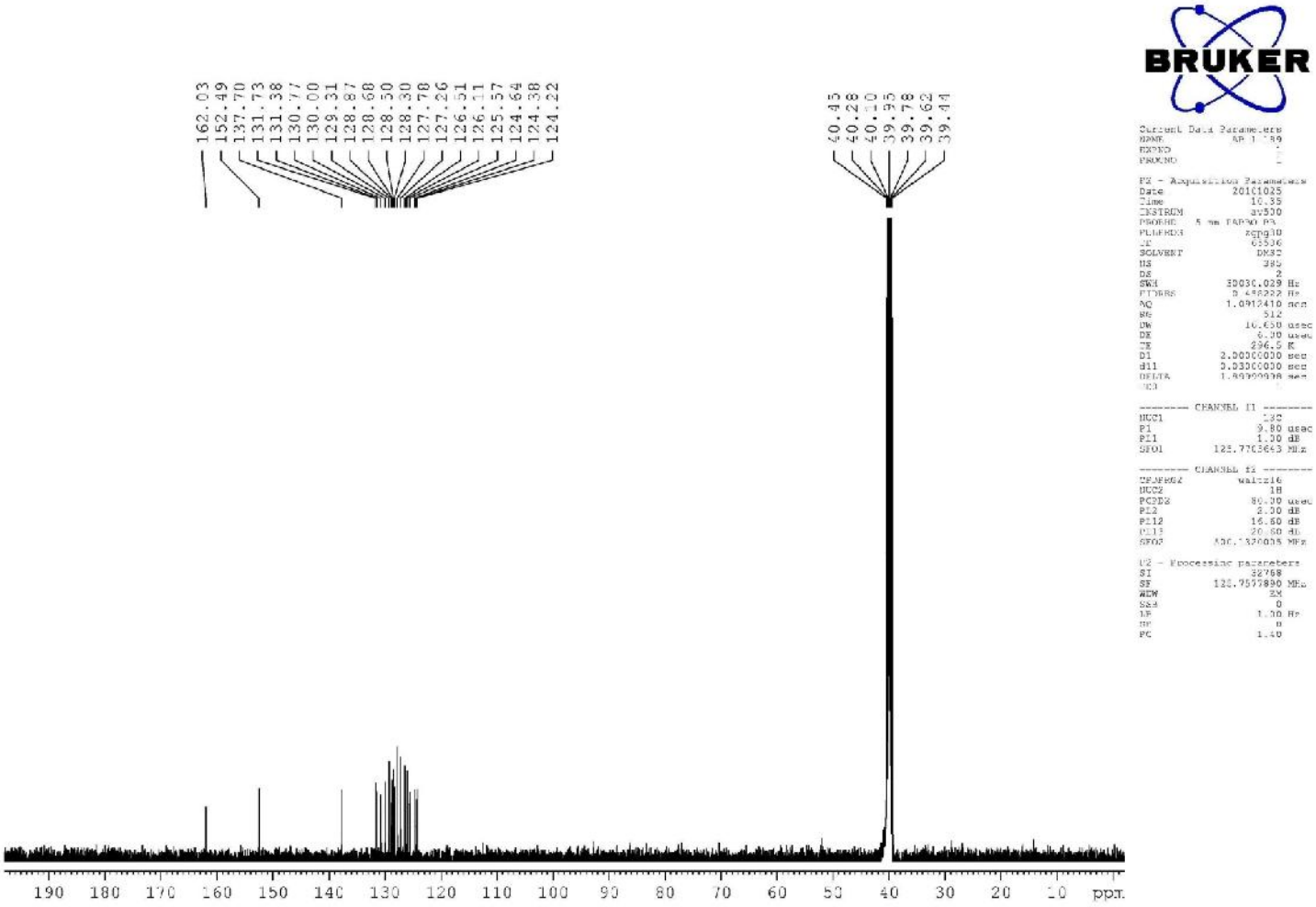


**Fig. S28** $^{13}$C NMR spectra of **4a** recorded in DMSO-$d_6$.

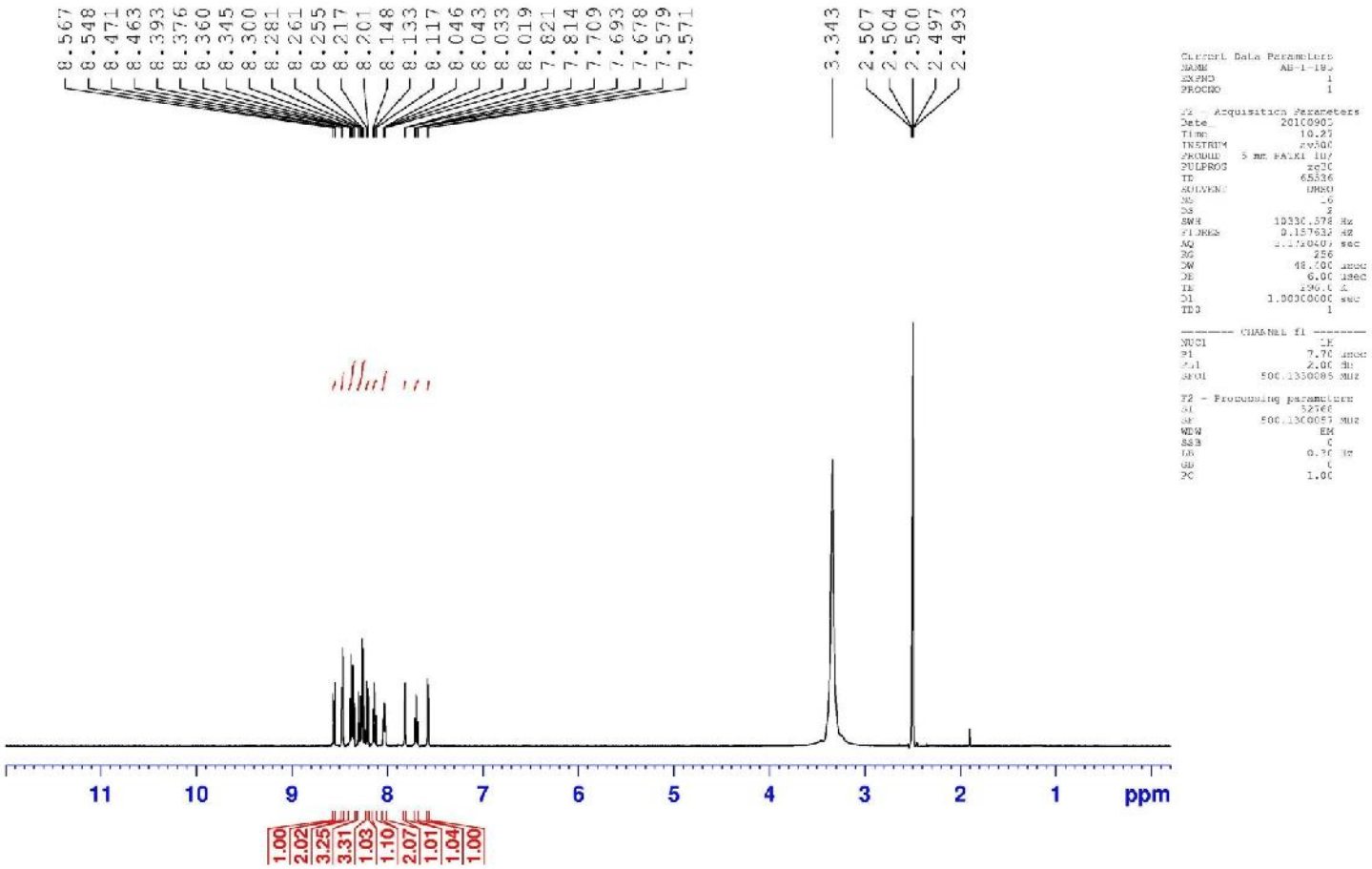


**Fig. S29** $^{1}$H NMR spectra of **4b** recorded in DMSO-$d_6$.

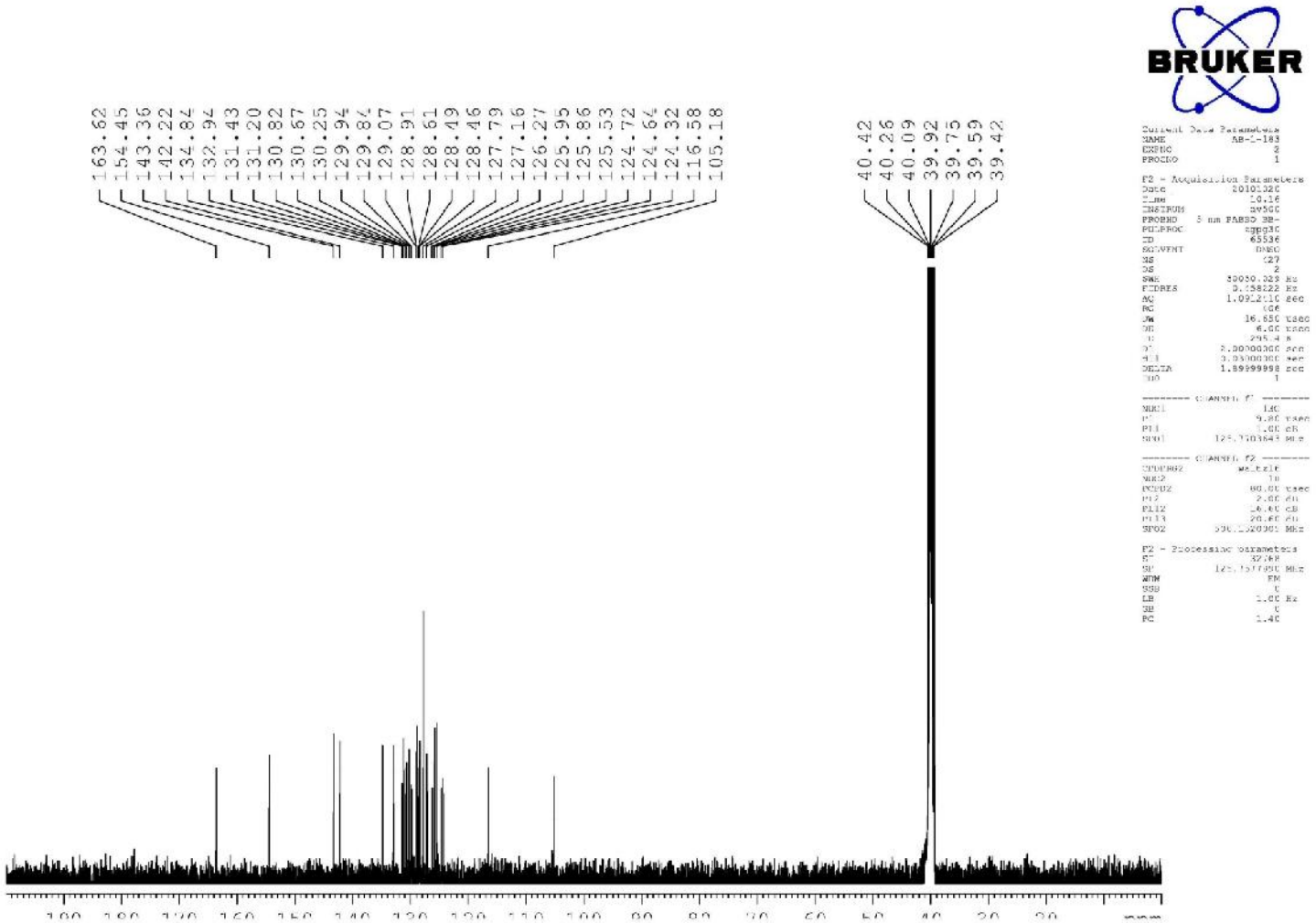


**Fig. S30** $^{13}$C NMR spectra of **4b** recorded in DMSO-$d_6$.

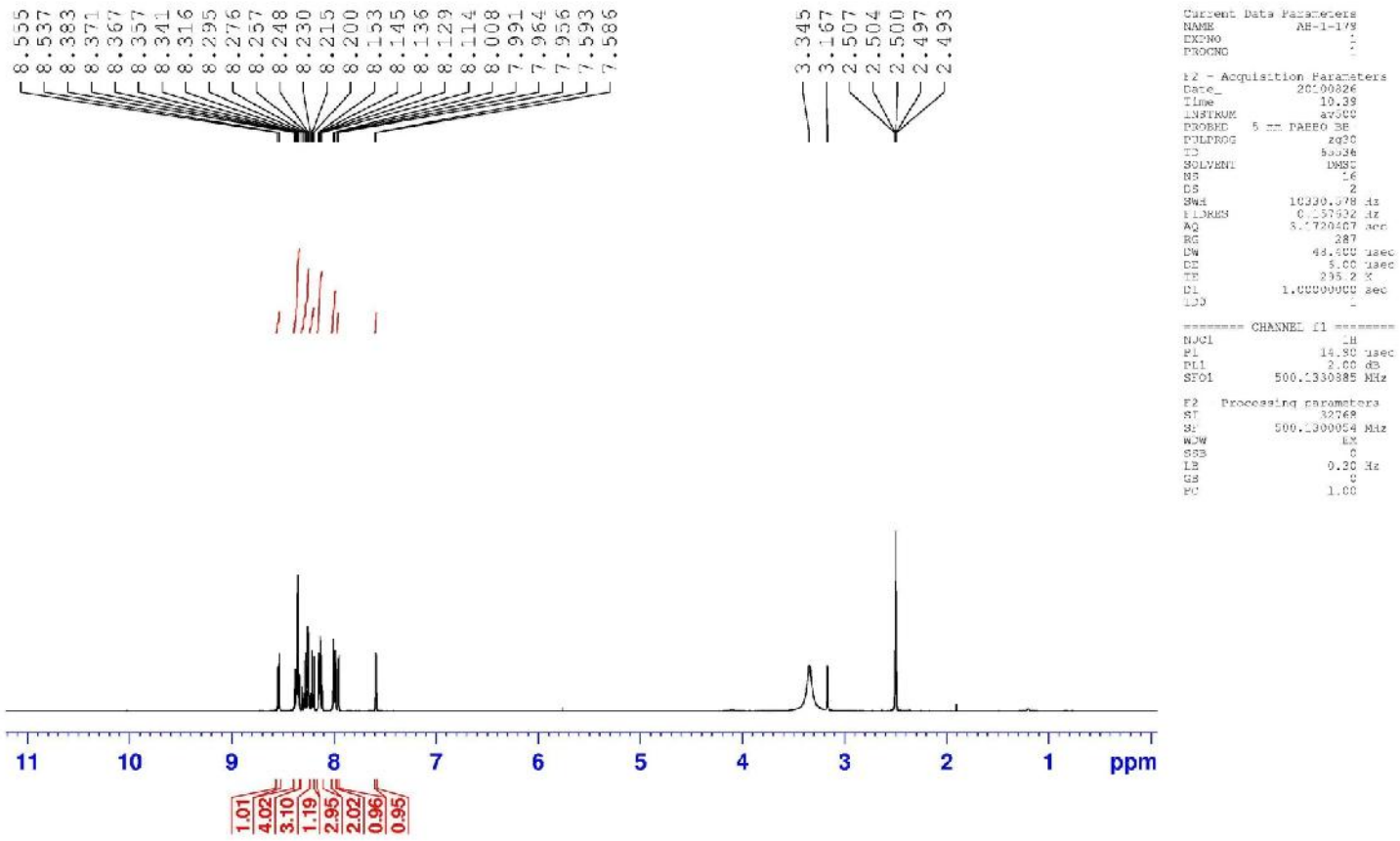


**Fig. S31** $^{1}$H NMR spectra of **4c** recorded in DMSO-$d_6$.

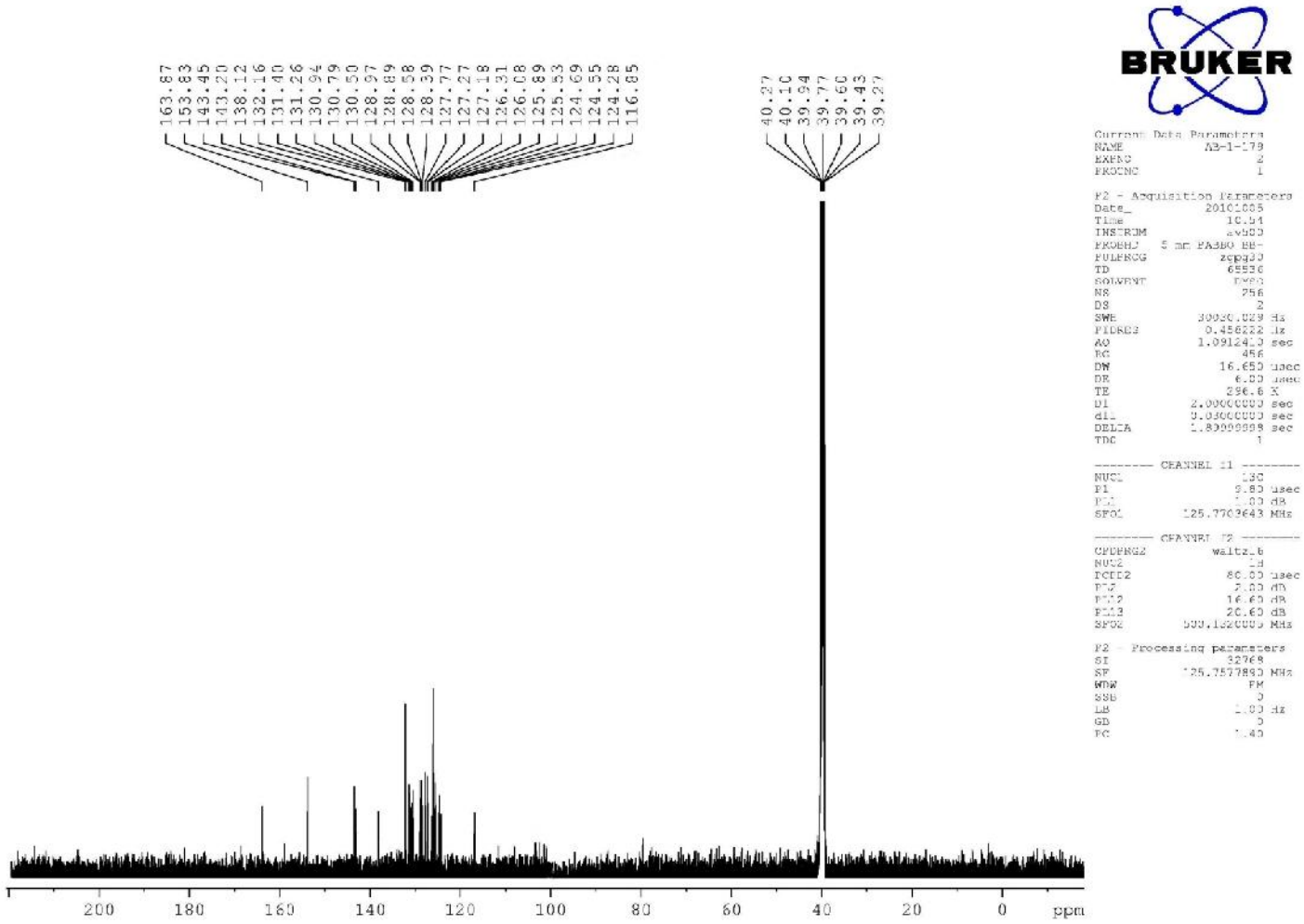


**Fig. S32** $^{13}$C NMR spectra of **4c** recorded in DMSO-$d_6$.

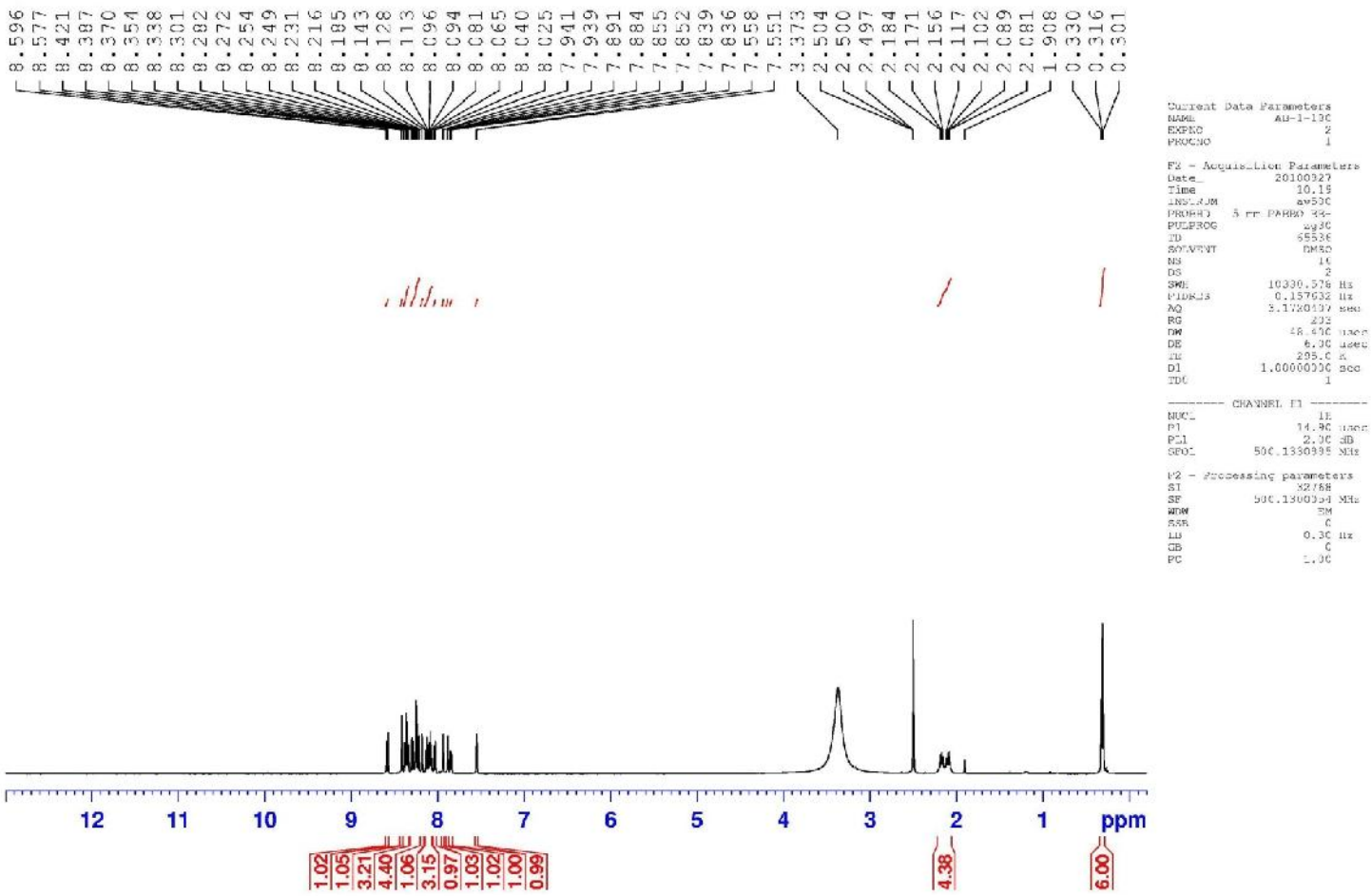


**Fig. S33** $^{1}$H NMR spectra of **4d** recorded in DMSO-$d_6$.

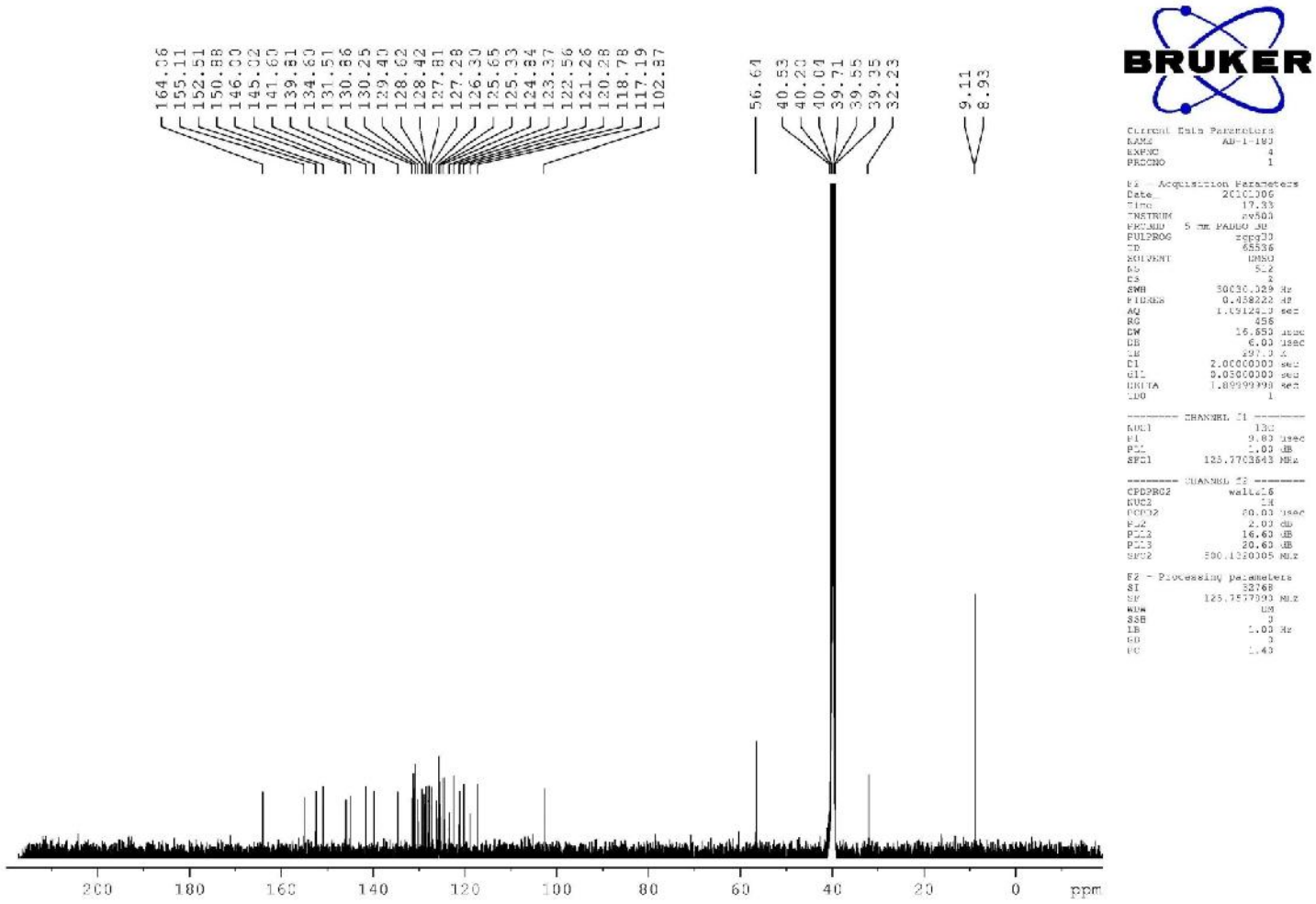


**Fig. S34** $^{13}$C NMR spectra of **4d** recorded in DMSO-$d_6$.

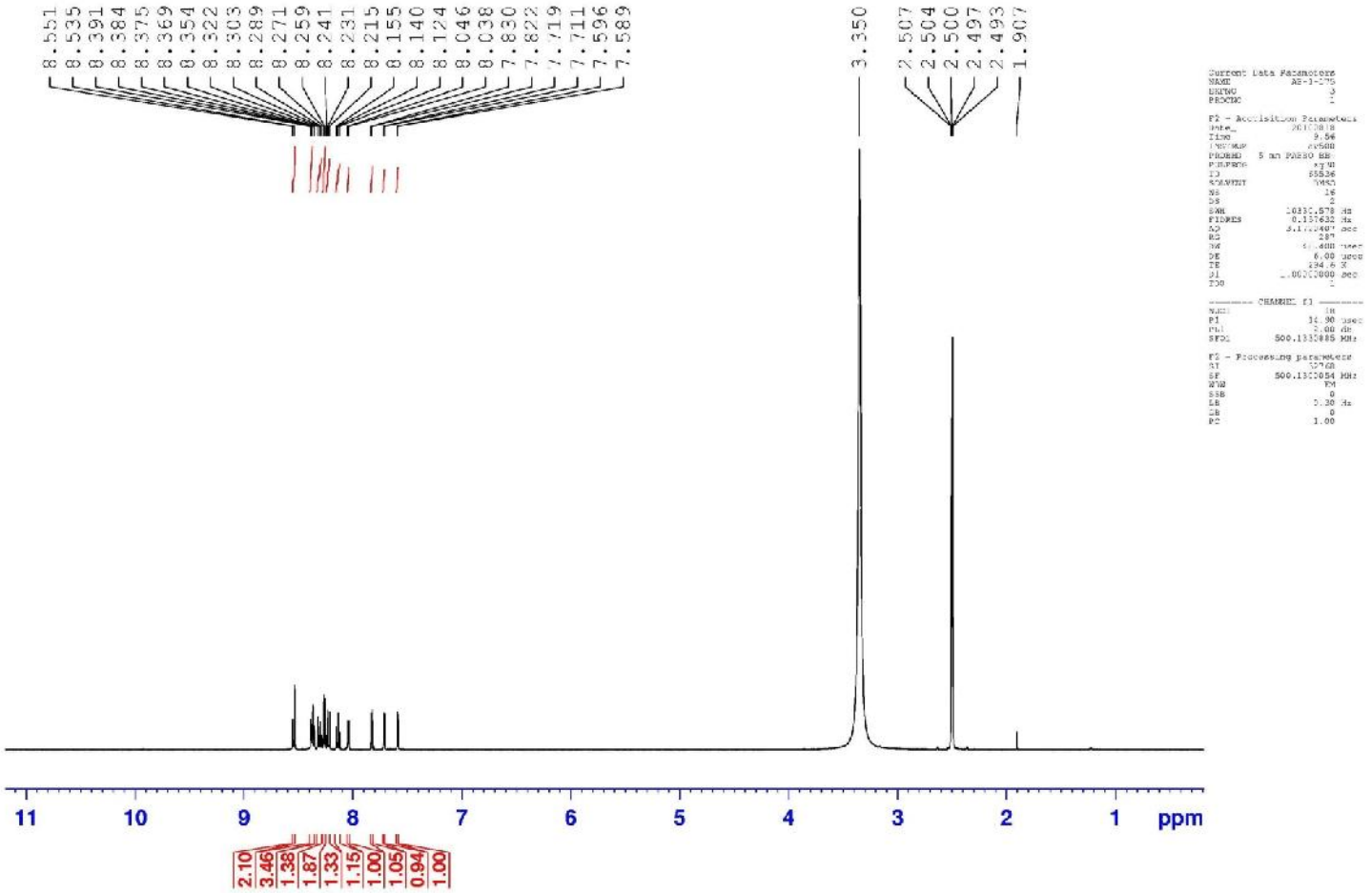


**Fig. S35** $^{1}$H NMR spectra of **4e** recorded in DMSO-$d_6$.

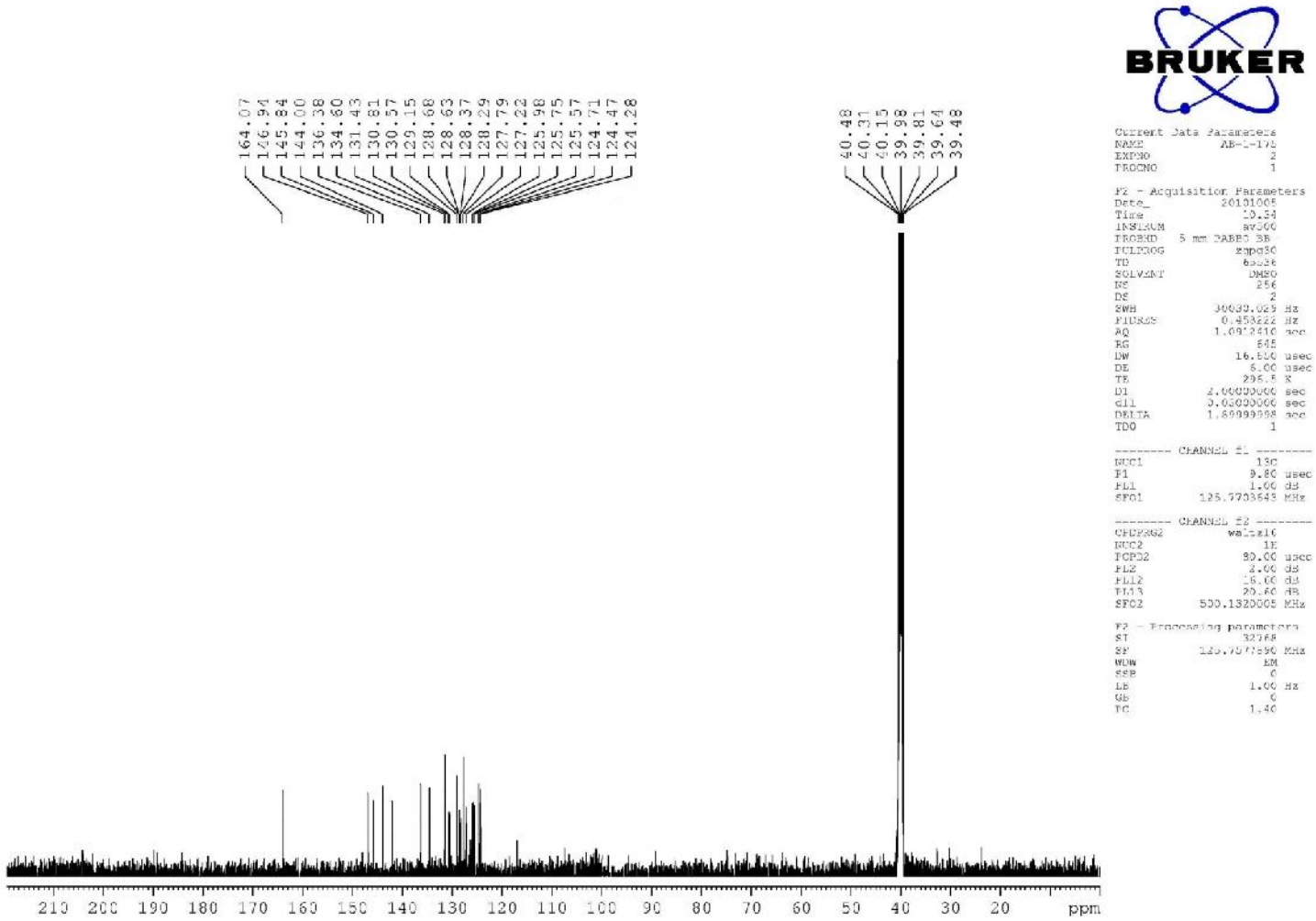


**Fig. S36** $^{13}$C NMR spectra of **4e** recorded in DMSO-$d_6$.

**Table S1** XYZ coordinates for the optimized geometry of **4a**.

| At. No. | X | Y | Z |
|---|---|---|---|
| 6 | 3.206347000 | -0.694936000 | 0.533784000 |
| 6 | 2.447371000 | -1.618228000 | 1.246260000 |
| 6 | 1.073570000 | -1.322708000 | 1.283678000 |
| 6 | 0.743636000 | -0.162381000 | 0.598992000 |
| 16 | 2.164604000 | 0.565756000 | -0.109732000 |
| 1 | 2.896431000 | -2.475134000 | 1.736967000 |
| 1 | 0.343725000 | -1.910057000 | 1.826637000 |
| 6 | -0.563674000 | 0.494831000 | 0.467096000 |
| 6 | -0.640928000 | 1.884983000 | 0.671098000 |
| 6 | -1.751032000 | -0.227867000 | 0.157965000 |
| 6 | -1.848586000 | 2.563130000 | 0.624155000 |
| 1 | 0.266667000 | 2.430984000 | 0.907950000 |
| 6 | -2.999903000 | 0.472670000 | 0.125282000 |
| 6 | -1.758754000 | -1.628564000 | -0.167794000 |
| 6 | -3.047328000 | 1.879628000 | 0.368845000 |
| 1 | -1.874147000 | 3.633940000 | 0.804454000 |
| 6 | -4.212128000 | -0.229427000 | -0.157694000 |
| 6 | -2.915042000 | -2.293419000 | -0.444053000 |
| 1 | -0.815429000 | -2.158003000 | -0.216924000 |
| 6 | -4.314547000 | 2.553027000 | 0.344137000 |
| 6 | -5.460632000 | 0.466100000 | -0.172403000 |
| 6 | -4.185037000 | -1.629174000 | -0.432734000 |
| 1 | -2.886882000 | -3.350482000 | -0.694761000 |
| 6 | -5.468594000 | 1.877857000 | 0.089767000 |
| 1 | -4.331875000 | 3.622464000 | 0.535017000 |
| 6 | -6.638365000 | -0.247982000 | -0.445385000 |
| 6 | -5.388129000 | -2.301486000 | -0.703587000 |
| 1 | -6.420922000 | 2.400926000 | 0.076224000 |
| 1 | -7.586752000 | 0.282232000 | -0.453060000 |
| 6 | -6.600615000 | -1.616368000 | -0.706517000 |
| 1 | -5.362058000 | -3.367049000 | -0.914542000 |
| 1 | -7.522180000 | -2.150700000 | -0.916890000 |
| 6 | 4.620358000 | -0.798227000 | 0.368872000 |
| 6 | 5.510265000 | 0.018640000 | -0.274292000 |
| 1 | 5.053485000 | -1.677812000 | 0.837196000 |
| 6 | 5.122931000 | 1.219162000 | -0.942601000 |
| 7 | 4.780355000 | 2.194042000 | -1.479362000 |
| 6 | 6.960172000 | -0.290376000 | -0.319602000 |
| 8 | 7.793455000 | 0.396363000 | -0.871608000 |
| 8 | 7.276282000 | -1.442221000 | 0.330306000 |
| 1 | 8.237745000 | -1.538147000 | 0.233780000 |

**Table S2** XYZ coordinates for the optimized geometry of **4b**.

| At. No. | X | Y | Z |
|---|---|---|---|
| 6 | 1.400876000 | -1.355312000 | 0.602404000 |
| 6 | 0.524823000 | -2.213182000 | 1.229685000 |
| 6 | -0.812158000 | -1.738123000 | 1.272024000 |
| 6 | -0.985487000 | -0.506978000 | 0.678220000 |
| 16 | 0.545038000 | 0.066684000 | 0.041280000 |
| 1 | 0.838570000 | -3.145148000 | 1.686055000 |
| 1 | -1.619918000 | -2.265834000 | 1.765125000 |
| 6 | -2.193237000 | 0.326866000 | 0.570018000 |
| 6 | -2.108700000 | 1.686892000 | 0.916866000 |
| 6 | -3.442342000 | -0.198437000 | 0.135501000 |
| 6 | -3.215828000 | 2.521168000 | 0.883058000 |
| 1 | -1.154219000 | 2.081300000 | 1.251251000 |
| 6 | -4.589258000 | 0.659684000 | 0.117356000 |
| 6 | -3.608382000 | -1.551116000 | -0.324544000 |
| 6 | -4.473411000 | 2.030809000 | 0.500808000 |
| 1 | -3.117145000 | 3.563505000 | 1.173102000 |
| 6 | -5.861391000 | 0.152961000 | -0.292454000 |
| 6 | -4.820469000 | -2.029286000 | -0.720449000 |
| 1 | -2.737279000 | -2.192852000 | -0.372581000 |
| 6 | -5.641858000 | 2.864627000 | 0.483493000 |
| 6 | -7.008931000 | 1.005369000 | -0.296901000 |
| 6 | -5.994729000 | -1.206539000 | -0.705300000 |
| 1 | -4.912266000 | -3.054015000 | -1.070766000 |
| 6 | -6.854246000 | 2.375101000 | 0.106193000 |
| 1 | -5.535713000 | 3.904134000 | 0.781740000 |
| 6 | -8.248536000 | 0.481699000 | -0.697799000 |
| 6 | -7.254472000 | -1.685685000 | -1.100175000 |
| 1 | -7.730391000 | 3.017884000 | 0.099566000 |
| 1 | -9.119900000 | 1.130874000 | -0.698532000 |
| 6 | -8.368037000 | -0.849123000 | -1.093202000 |
| 1 | -7.350796000 | -2.721206000 | -1.414987000 |
| 1 | -9.335222000 | -1.235407000 | -1.400774000 |
| 6 | 2.840479000 | -1.526788000 | 0.379123000 |
| 6 | 3.697195000 | -0.429693000 | 0.218613000 |
| 6 | 3.407051000 | -2.814156000 | 0.320716000 |
| 6 | 5.080837000 | -0.583005000 | 0.003070000 |
| 1 | 3.288223000 | 0.575155000 | 0.276725000 |
| 6 | 4.776218000 | -2.982513000 | 0.123809000 |
| 1 | 2.765534000 | -3.684726000 | 0.410460000 |
| 6 | 5.617612000 | -1.886698000 | -0.038620000 |
| 1 | 5.191442000 | -3.984673000 | 0.082565000 |
| 1 | 6.675635000 | -2.044530000 | -0.198894000 |
| 6 | 5.849422000 | 0.644603000 | -0.153379000 |
| 6 | 7.175571000 | 0.863756000 | -0.374377000 |

| | | | |
|---|---|---|---|
| 1 | 5.256613000 | 1.551960000 | -0.083336000 |
| 6 | 8.160878000 | -0.165401000 | -0.505663000 |
| 7 | 8.954068000 | -1.010287000 | -0.610416000 |
| 6 | 7.722732000 | 2.244822000 | -0.502718000 |
| 8 | 8.891005000 | 2.498510000 | -0.700344000 |
| 8 | 6.774225000 | 3.206433000 | -0.375780000 |
| 1 | 7.242589000 | 4.051159000 | -0.477551000 |

**Table S3** XYZ coordinates for the optimized geometry of **4c**.

| At. No. | X | Y | Z |
|---|---|---|---|
| 6 | 1.266663000 | -0.575916000 | 0.666594000 |
| 6 | 0.503864000 | -1.493534000 | 1.361461000 |
| 6 | -0.882731000 | -1.207161000 | 1.359175000 |
| 6 | -1.214803000 | -0.063729000 | 0.661190000 |
| 16 | 0.229154000 | 0.663704000 | -0.013571000 |
| 1 | 0.933108000 | -2.332743000 | 1.896339000 |
| 1 | -1.617058000 | -1.797772000 | 1.893624000 |
| 6 | -2.524435000 | 0.581074000 | 0.483554000 |
| 6 | -2.629521000 | 1.967012000 | 0.698911000 |
| 6 | -3.688558000 | -0.151481000 | 0.117454000 |
| 6 | -3.842411000 | 2.631958000 | 0.604319000 |
| 1 | -1.739565000 | 2.520449000 | 0.981716000 |
| 6 | -4.944229000 | 0.533247000 | 0.037823000 |
| 6 | -3.664651000 | -1.550526000 | -0.215291000 |
| 6 | -5.020337000 | 1.937116000 | 0.290759000 |
| 1 | -3.889442000 | 3.700624000 | 0.793896000 |
| 6 | -6.134284000 | -0.181941000 | -0.301536000 |
| 6 | -4.799157000 | -2.227822000 | -0.545429000 |
| 1 | -2.712681000 | -2.066759000 | -0.221891000 |
| 6 | -6.294242000 | 2.594569000 | 0.216950000 |
| 6 | -7.390175000 | 0.497814000 | -0.364191000 |
| 6 | -6.077178000 | -1.579339000 | -0.585063000 |
| 1 | -4.747241000 | -3.283091000 | -0.800127000 |
| 6 | -7.427625000 | 1.907304000 | -0.091698000 |
| 1 | -6.333802000 | 3.662072000 | 0.415839000 |
| 6 | -8.545813000 | -0.228954000 | -0.692649000 |
| 6 | -7.258880000 | -2.264456000 | -0.911812000 |
| 1 | -8.385312000 | 2.418331000 | -0.141554000 |
| 1 | -9.499836000 | 0.289236000 | -0.737180000 |
| 6 | -8.478943000 | -1.594573000 | -0.961879000 |
| 1 | -7.210272000 | -3.328113000 | -1.128532000 |
| 1 | -9.383658000 | -2.139039000 | -1.215377000 |
| 6 | 2.712728000 | -0.562627000 | 0.470470000 |
| 6 | 3.400888000 | 0.608451000 | 0.088015000 |
| 6 | 3.473583000 | -1.734931000 | 0.661082000 |
| 6 | 4.774010000 | 0.619868000 | -0.093070000 |
| 1 | 2.848134000 | 1.532151000 | -0.053041000 |
| 6 | 4.846544000 | -1.723478000 | 0.488923000 |
| 1 | 2.977512000 | -2.662543000 | 0.925235000 |
| 6 | 5.538448000 | -0.551408000 | 0.107380000 |
| 1 | 5.254843000 | 1.544797000 | -0.383719000 |
| 1 | 5.408407000 | -2.641359000 | 0.639713000 |
| 6 | 6.975712000 | -0.657194000 | -0.047570000 |
| 6 | 7.926335000 | 0.261819000 | -0.388467000 |

| | | | |
|---|---|---|---|
| 1 | 7.371137000 | -1.650637000 | 0.143862000 |
| 6 | 7.657091000 | 1.634396000 | -0.684938000 |
| 7 | 7.422153000 | 2.749186000 | -0.923271000 |
| 6 | 9.365023000 | -0.107676000 | -0.479095000 |
| 8 | 10.251770000 | 0.664019000 | -0.775949000 |
| 8 | 9.599210000 | -1.414576000 | -0.193094000 |
| 1 | 10.558864000 | -1.532001000 | -0.284656000 |

**Table S4** XYZ coordinates for the optimized geometry of **4d**.

| At. No. | X | Y | Z |
|---|---|---|---|
| 6 | 1.207480000 | -1.307574000 | -0.737551000 |
| 6 | 2.110460000 | -2.187337000 | -1.296705000 |
| 6 | 3.450286000 | -1.722185000 | -1.285549000 |
| 6 | 3.603578000 | -0.475257000 | -0.718311000 |
| 16 | 2.047666000 | 0.125619000 | -0.175583000 |
| 1 | 1.814157000 | -3.129489000 | -1.743202000 |
| 1 | 4.277031000 | -2.268064000 | -1.724528000 |
| 6 | 4.810396000 | 0.354256000 | -0.578698000 |
| 6 | 4.749872000 | 1.706060000 | -0.961859000 |
| 6 | 6.037571000 | -0.166645000 | -0.080380000 |
| 6 | 5.860694000 | 2.533972000 | -0.904592000 |
| 1 | 3.812498000 | 2.097764000 | -1.344272000 |
| 6 | 7.189102000 | 0.684355000 | -0.038116000 |
| 6 | 6.174924000 | -1.507477000 | 0.421678000 |
| 6 | 7.098850000 | 2.045728000 | -0.460922000 |
| 1 | 5.780933000 | 3.569269000 | -1.224293000 |
| 6 | 8.440238000 | 0.180367000 | 0.435034000 |
| 6 | 7.366605000 | -1.982925000 | 0.878316000 |
| 1 | 5.297500000 | -2.141634000 | 0.451805000 |
| 6 | 8.271905000 | 2.872013000 | -0.419137000 |
| 6 | 9.593147000 | 1.025161000 | 0.462804000 |
| 6 | 8.546762000 | -1.168578000 | 0.888451000 |
| 1 | 7.436552000 | -2.998485000 | 1.259121000 |
| 6 | 9.464952000 | 2.384681000 | 0.018115000 |
| 1 | 8.185295000 | 3.904089000 | -0.748042000 |
| 6 | 10.811982000 | 0.504213000 | 0.926215000 |
| 6 | 9.786270000 | -1.645163000 | 1.345683000 |
| 1 | 10.345094000 | 3.021564000 | 0.042465000 |
| 1 | 11.687524000 | 1.147517000 | 0.944516000 |
| 6 | 10.905508000 | -0.816313000 | 1.361090000 |
| 1 | 9.862316000 | -2.672611000 | 1.691107000 |
| 1 | 11.856806000 | -1.200596000 | 1.717058000 |
| 6 | -0.240370000 | -1.460004000 | -0.581783000 |
| 6 | -1.084200000 | -0.339197000 | -0.432319000 |
| 6 | -0.818223000 | -2.749430000 | -0.579347000 |
| 6 | -2.452604000 | -0.511128000 | -0.287013000 |
| 1 | -0.654610000 | 0.658419000 | -0.448176000 |
| 6 | -2.189555000 | -2.926547000 | -0.446354000 |
| 1 | -0.174174000 | -3.618481000 | -0.661444000 |
| 6 | -3.532587000 | 0.562619000 | -0.102470000 |
| 6 | -3.010455000 | -1.803764000 | -0.297054000 |
| 1 | -2.608567000 | -3.928752000 | -0.445823000 |
| 6 | -4.789395000 | -0.313135000 | -0.015138000 |
| 6 | -4.453150000 | -1.685116000 | -0.133688000 |

| | | | |
|---|---|---|---|
| 6 | -6.114616000 | 0.061579000 | 0.131623000 |
| 6 | -5.443202000 | -2.671905000 | -0.091604000 |
| 6 | -7.133533000 | -0.924014000 | 0.169482000 |
| 1 | -6.379232000 | 1.103578000 | 0.227949000 |
| 6 | -6.767048000 | -2.286134000 | 0.061889000 |
| 1 | -5.186301000 | -3.723325000 | -0.178261000 |
| 1 | -7.546053000 | -3.042798000 | 0.096358000 |
| 6 | -3.523082000 | 1.467176000 | -1.378206000 |
| 6 | -4.451201000 | 2.685255000 | -1.432733000 |
| 1 | -3.731012000 | 0.818595000 | -2.237821000 |
| 1 | -2.491886000 | 1.817824000 | -1.510524000 |
| 1 | -4.356176000 | 3.165363000 | -2.412385000 |
| 1 | -5.505294000 | 2.428653000 | -1.301992000 |
| 1 | -4.190934000 | 3.435418000 | -0.681547000 |
| 6 | -3.216225000 | 1.351751000 | 1.214183000 |
| 6 | -4.352470000 | 2.102107000 | 1.921677000 |
| 1 | -2.405650000 | 2.053204000 | 0.977657000 |
| 1 | -2.792778000 | 0.639287000 | 1.931130000 |
| 1 | -3.943191000 | 2.652706000 | 2.775239000 |
| 1 | -4.865674000 | 2.823126000 | 1.282417000 |
| 1 | -5.103336000 | 1.410500000 | 2.312703000 |
| 6 | -8.547316000 | -0.641576000 | 0.315494000 |
| 6 | -9.241951000 | 0.533455000 | 0.387991000 |
| 1 | -9.174632000 | -1.526512000 | 0.373335000 |
| 6 | -8.647784000 | 1.831965000 | 0.314449000 |
| 7 | -8.148368000 | 2.881643000 | 0.249157000 |
| 6 | -10.720667000 | 0.552532000 | 0.542678000 |
| 8 | -11.389466000 | 1.562269000 | 0.606644000 |
| 8 | -11.267189000 | -0.689514000 | 0.607766000 |
| 1 | -12.222734000 | -0.546606000 | 0.705465000 |

**Table S5** XYZ coordinates for the optimized geometry of **4e**.

| At. No. | X | Y | Z |
|---|---|---|---|
| 6 | -1.446570000 | -0.453867000 | 0.157048000 |
| 6 | -0.941616000 | 0.604902000 | 0.889165000 |
| 6 | 0.467348000 | 0.593178000 | 1.008480000 |
| 6 | 1.074819000 | -0.472912000 | 0.374371000 |
| 16 | -0.134880000 | -1.477438000 | -0.401923000 |
| 1 | -1.572592000 | 1.358632000 | 1.347272000 |
| 1 | 1.024095000 | 1.323782000 | 1.582460000 |
| 6 | 2.492464000 | -0.857840000 | 0.331181000 |
| 6 | 2.834541000 | -2.199038000 | 0.583039000 |
| 6 | 3.527953000 | 0.080647000 | 0.059403000 |
| 6 | 4.153462000 | -2.624055000 | 0.614094000 |
| 1 | 2.041523000 | -2.909195000 | 0.795396000 |
| 6 | 4.891310000 | -0.356380000 | 0.110078000 |
| 6 | 3.274503000 | 1.449053000 | -0.303238000 |
| 6 | 5.204594000 | -1.720378000 | 0.396621000 |
| 1 | 4.381893000 | -3.664063000 | 0.829483000 |
| 6 | 5.953323000 | 0.568959000 | -0.132077000 |
| 6 | 4.288739000 | 2.326753000 | -0.540027000 |
| 1 | 2.248073000 | 1.777318000 | -0.409929000 |
| 6 | 6.579843000 | -2.127078000 | 0.453805000 |
| 6 | 7.314282000 | 0.137020000 | -0.064679000 |
| 6 | 5.663238000 | 1.929953000 | -0.447534000 |
| 1 | 4.064650000 | 3.352774000 | -0.819468000 |
| 6 | 7.588754000 | -1.239618000 | 0.237809000 |
| 1 | 6.799049000 | -3.167695000 | 0.676732000 |
| 6 | 8.339543000 | 1.067329000 | -0.298959000 |
| 6 | 6.721613000 | 2.824363000 | -0.676809000 |
| 1 | 8.625521000 | -1.561318000 | 0.286675000 |
| 1 | 9.373459000 | 0.737588000 | -0.244585000 |
| 6 | 8.044508000 | 2.395510000 | -0.600165000 |
| 1 | 6.495729000 | 3.859483000 | -0.917906000 |
| 1 | 8.851394000 | 3.099795000 | -0.779234000 |
| 6 | -2.818802000 | -0.759755000 | -0.159756000 |
| 6 | -3.324759000 | -1.887796000 | -0.795806000 |
| 16 | -4.101883000 | 0.352956000 | 0.258386000 |
| 6 | -4.719118000 | -1.860655000 | -0.939055000 |
| 1 | -2.699095000 | -2.704930000 | -1.134999000 |
| 6 | -5.323436000 | -0.718442000 | -0.420109000 |
| 1 | -5.294937000 | -2.652669000 | -1.405371000 |
| 6 | -6.727998000 | -0.484086000 | -0.450793000 |
| 6 | -7.472895000 | 0.566926000 | 0.016410000 |
| 1 | -7.295271000 | -1.279314000 | -0.926420000 |
| 6 | -6.897225000 | 1.698036000 | 0.668724000 |
| 7 | -6.399554000 | 2.608662000 | 1.197395000 |

| | | | |
|---|---|---|---|
| 6 | -8.947772000 | 0.601076000 | -0.124585000 |
| 8 | -9.657250000 | 1.502345000 | 0.270168000 |
| 8 | -9.445246000 | -0.498118000 | -0.752608000 |
| 1 | -10.406345000 | -0.363741000 | -0.785571000 |

**Table S6** Photophysical data for the dyes measured in different solvents.

| Dye | $\lambda_{abs}$, nm | | | | $\lambda_{em}$, nm | | | | Stokes shift, $cm^{-1}$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TOL | ACN | DCM | DMF | TOL | ACN | DCM | DMF | TOL | ACN | DCM | DMF |
| **4a** | 416 | 394 | 420 | 394 | 528 | 501 | 565 | 494 | 5099 | 5420 | 6110 | 5137 |
| **4b** | 364 | 361 | 363 | 368 | 469 | 457 | 442 | 448 | 6151 | 5819 | 4924 | 4852 |
| **4c** | 445 | 408 | 457 | 411 | 533 | 502 | 575 | 501 | 3710 | 4589 | 4491 | 4371 |
| **4d** | 410 | 389 | 415 | 385 | 518 | 483 | 505 | 485 | 5085 | 5003 | 4294 | 5355 |
| **4e** | 415 | 383 | 420 | 385 | 553 | 529 | 584 | 521 | 6013 | 7206 | 6686 | 6999 |