# *Synthesis, x-ray structure and anion binding properties of a cryptand-like hybrid calixpyrrole*

Article

Accepted Version

**Synthesis, X-ray Structure and Anion Binding Properties of a Cryptand-Like Hybrid Calixpyrrole**

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**General experimental procedures**

Ethanol was dried on molecular sieves (4 Å). Pyrrole was distilled before use. All other chemicals were standard reagent grade and were used without further purification. All air-sensitive and/or moisture-sensitive reactions were conducted under an inert atmosphere. Thin-layer chromatography was carried out by using Merck $SiO_2$ 60F254 plastic plates. Compounds were visualized with vanillin or by examination under UV light. Column chromatography was conducted by using silica gel (Aldrich, 230–400 mesh, 60 Å). $^1$H NMR and $^{13}$C NMR spectra were recorded in $CDCl_3$ or $CD_2Cl_2$ by using a Varian 500 spectrometer at 500 and 125 MHz, respectively. Melting points were determined by using a Kofler hot-stage apparatus, and are not corrected. The TBA salts were dried in a vacuum oven for a least 24 h. Solvents were used as supplied in sealed ampoules, and care was taken to minimize exposure to moisture. However, trace amounts of water could not be removed owing to the extremely hydrophilic nature of the salts. Because water has been demonstrated to lower the values of the observed binding constants, the data given should be considered to be the minimum observable value if operating under strictly anhydrous conditions.

Mass spectra were obtained from an Applied Biosystems-MDS Sciex API 4000 triple quadrupole mass spectrometer (Concord, Ont., Canada), equipped with a Turbo-V ionspray (TIS) source. The operative parameters used were as follows: ionspray voltage (IS), 5.5 kV; gas source 1 (GS1), 25; gas source 2 (GS2), 25; turbo temperature (TEM), 300 °C; entrance potential (EP), 10 V; declustering potential (DP), 20 V; scan range, $m/z$ = 300–1500. Each sample for MS (ESI) was prepared by a 1:100 dilution of a dichloromethane solution (2 mg/mL) of the target compound with methanol, and it was infused by a syringe pump Harvard Mod. 22 (Harvard Apparatus, Holliston, MA, USA).

MS–MS product ions were produced by collisional induced dissociation (CID) of selected precursor ions in the LINAC collision cell (Q2) and mass-analyzed in the second mass filter (Q3). Additional experimental conditions for MS–MS product ions spectra included collision (CAD) gas, nitrogen; CAD gas pressure, 4 mPa; collision energy (CE), 30 eV, collision cell exit potential (CXP), 15V.

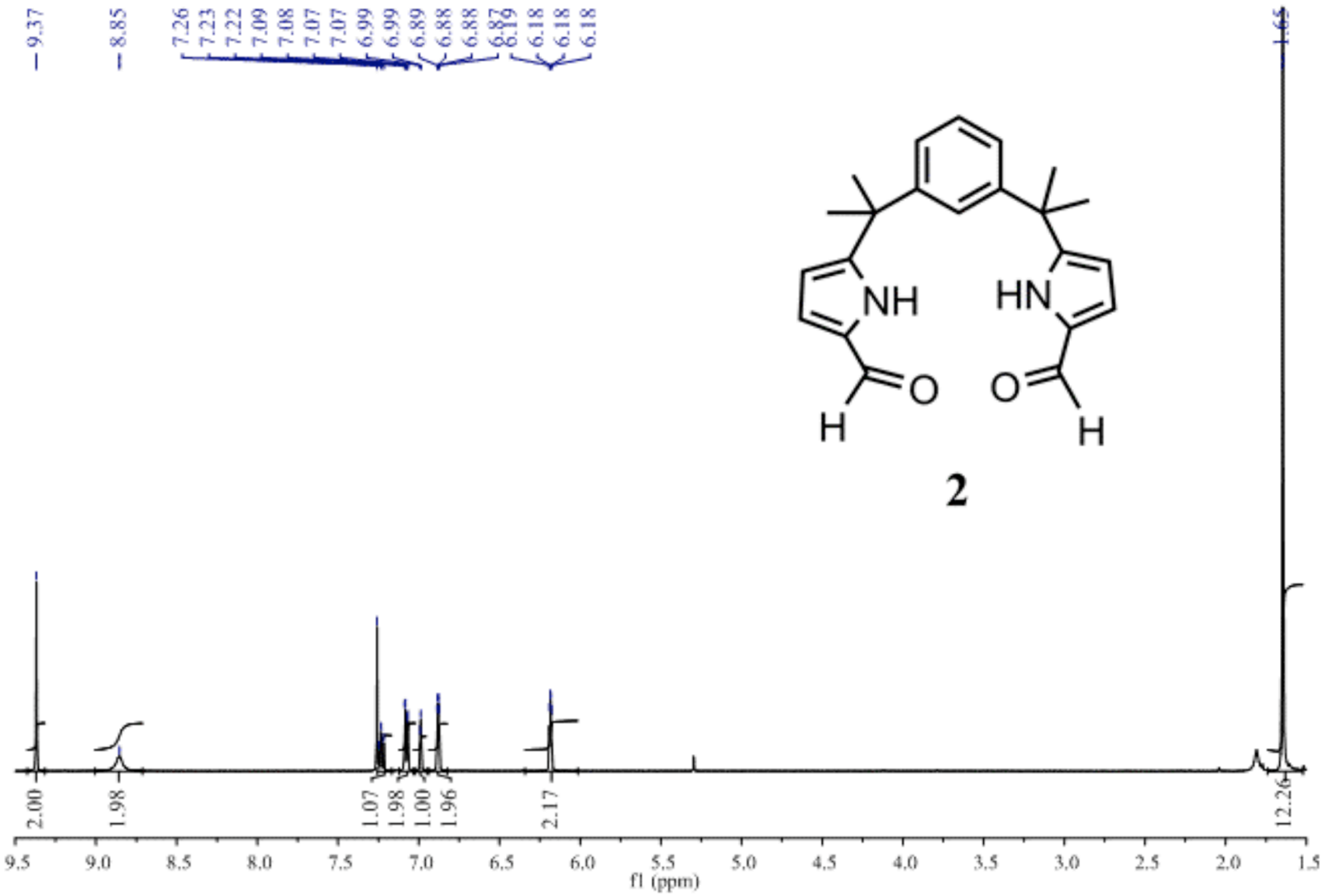



**Figure S1**. $^{1}H$ NMR ($CDCl_3$, 125 MHz) of 1,3-Bis[1'-(pyrrol-2-carboxaldehyde-5-yl)-1',1'-(dimethyl)methyl]benzene **2**

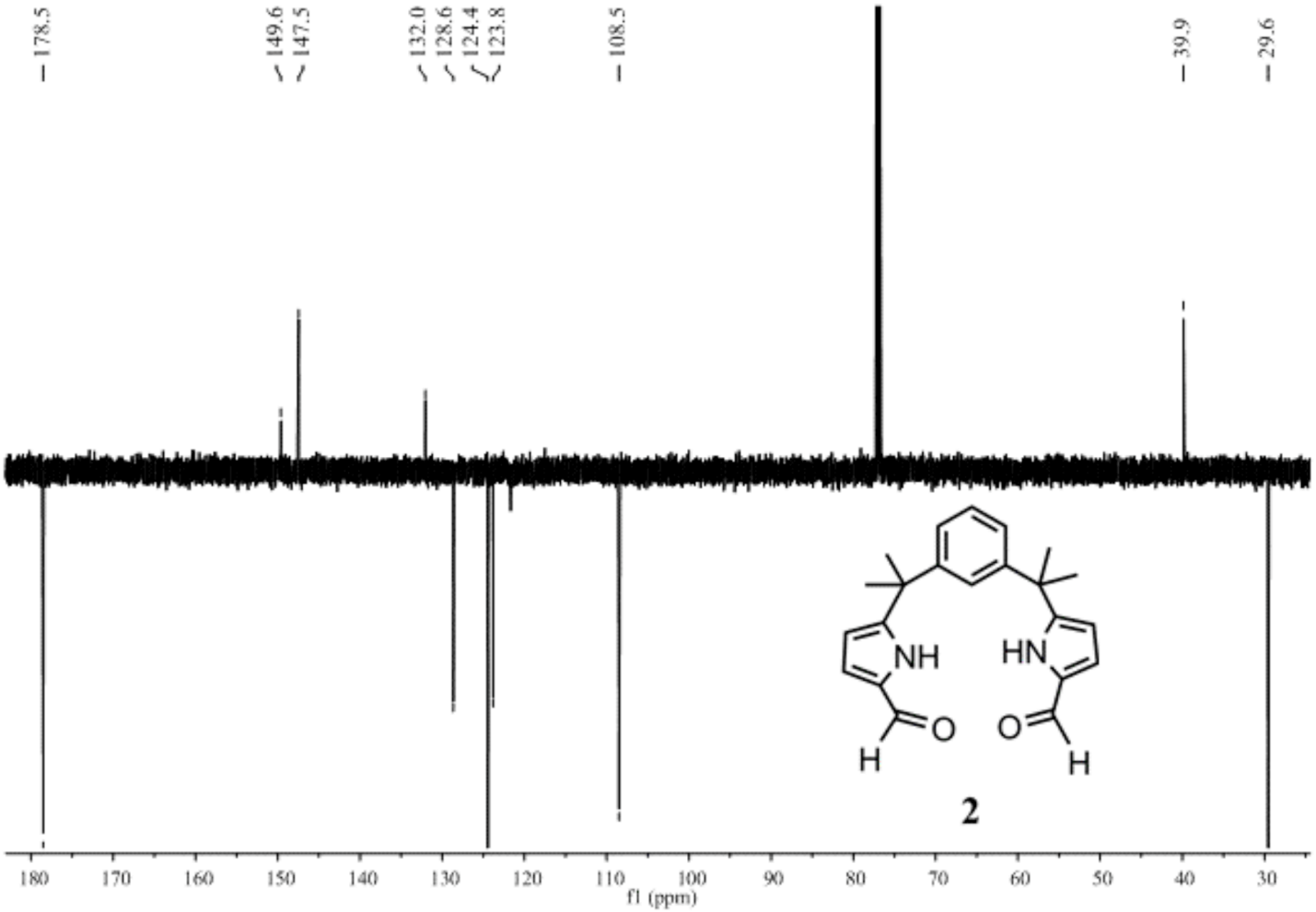



**Figure S2**. $^{13}C$ NMR ($CDCl_3$, 125 MHz) of 1,3-Bis[1'-(pyrrol-2-carboxaldehyde-5-yl)-1',1'-(dimethyl)methyl]benzene **2**

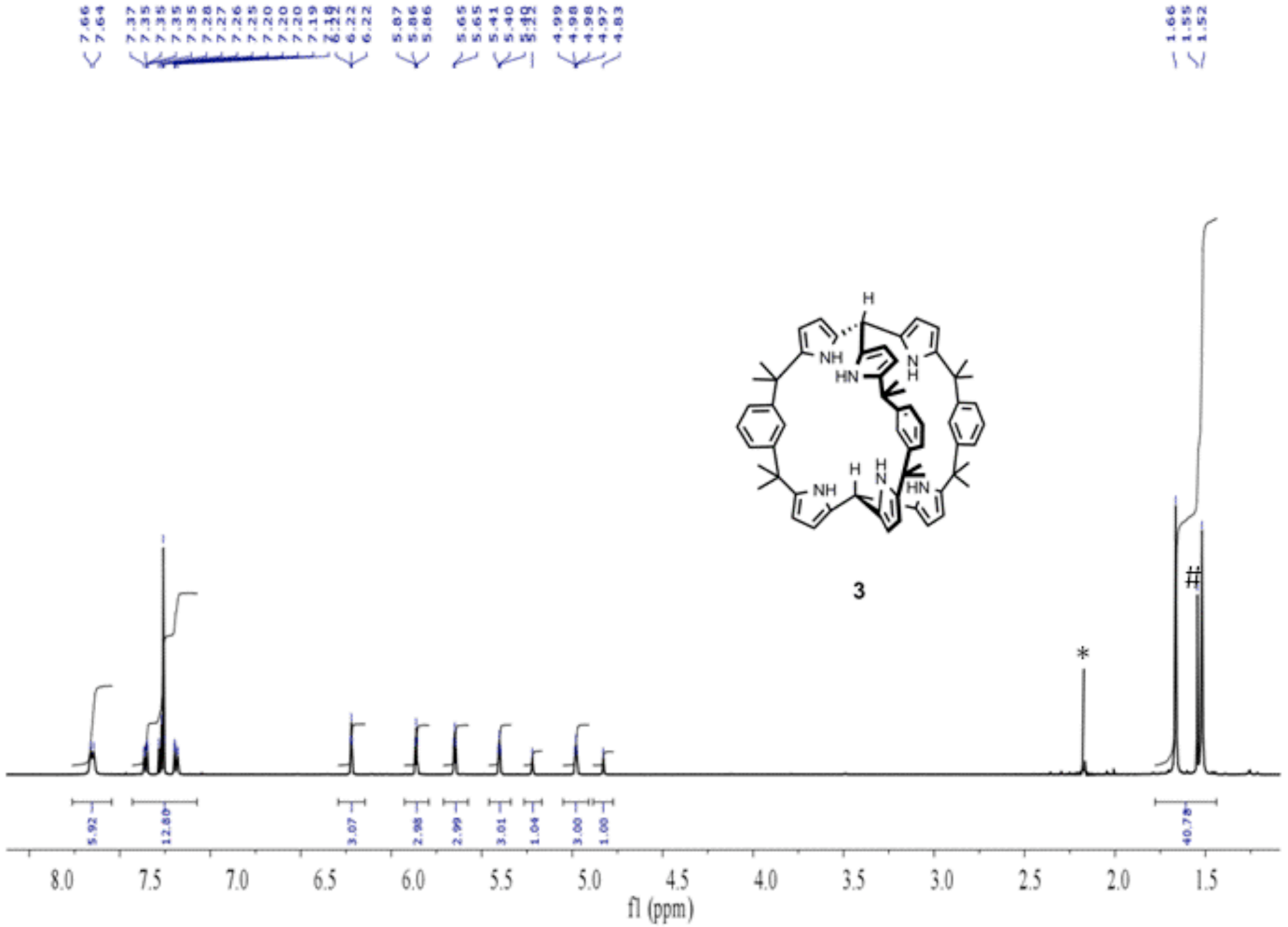



**Figure S3**. $^{1}H$ NMR ($CDCl_3$, 500 MHz) spectrum of cryptand *in*/*out*-**3**

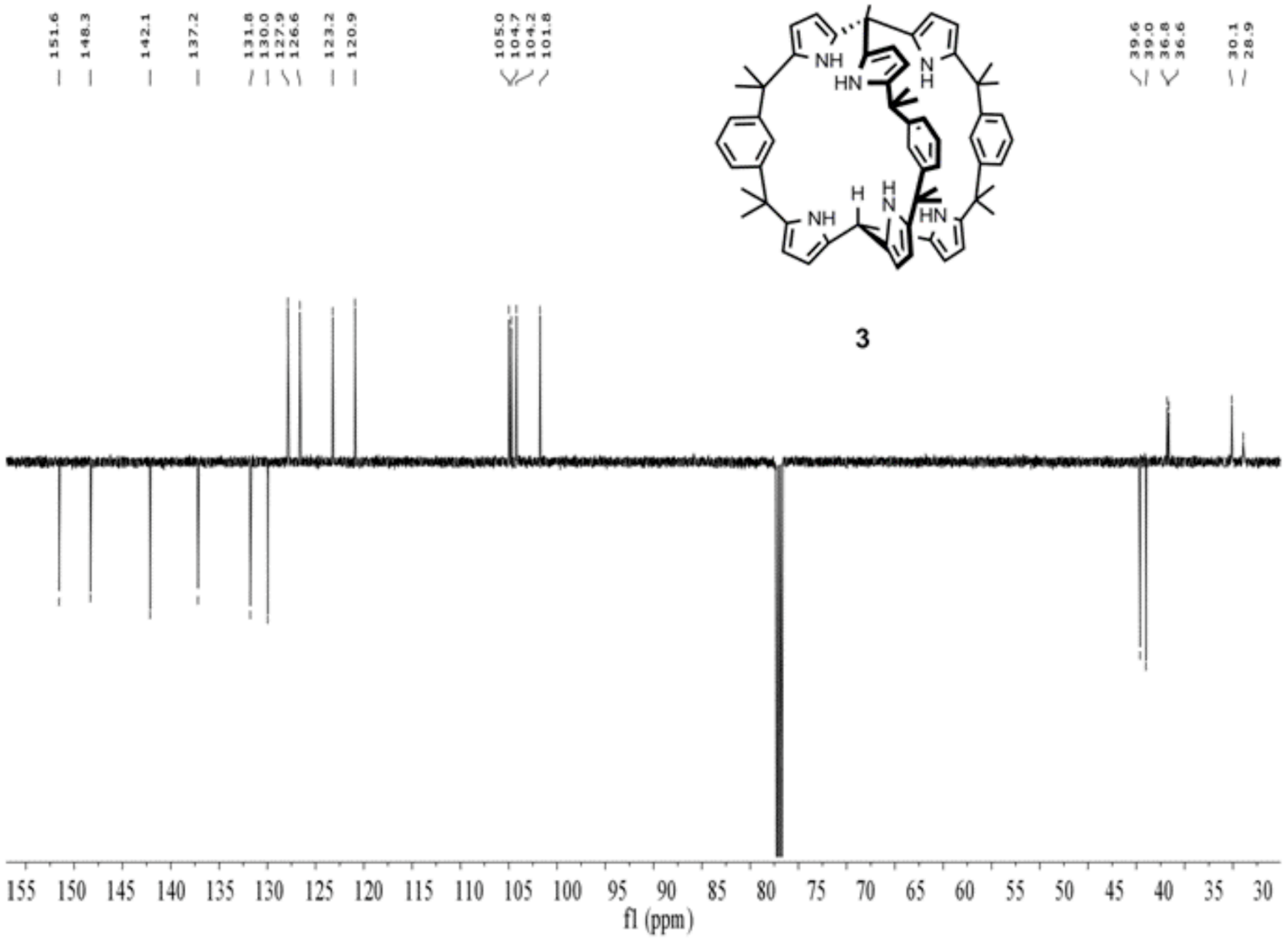



**Figure S4**. $^{13}C$ NMR ($CDCl_3$, 125 MHz) spectrum of cryptand *in*/*out*-**3**

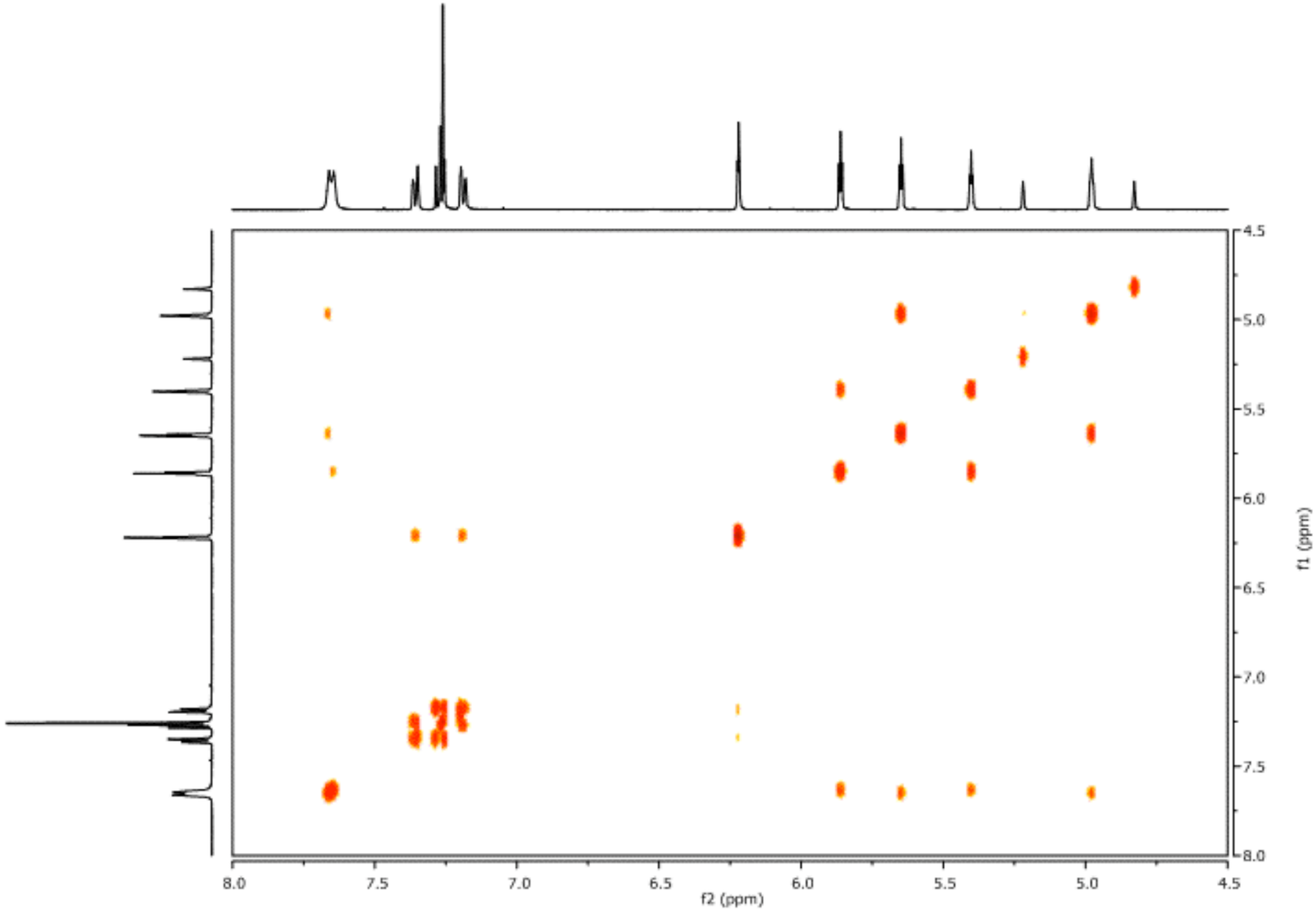



**Figure S5**. gCOSY ($CDCl_3$, 500 MHz) for cryptand *in*/*out*-**3**

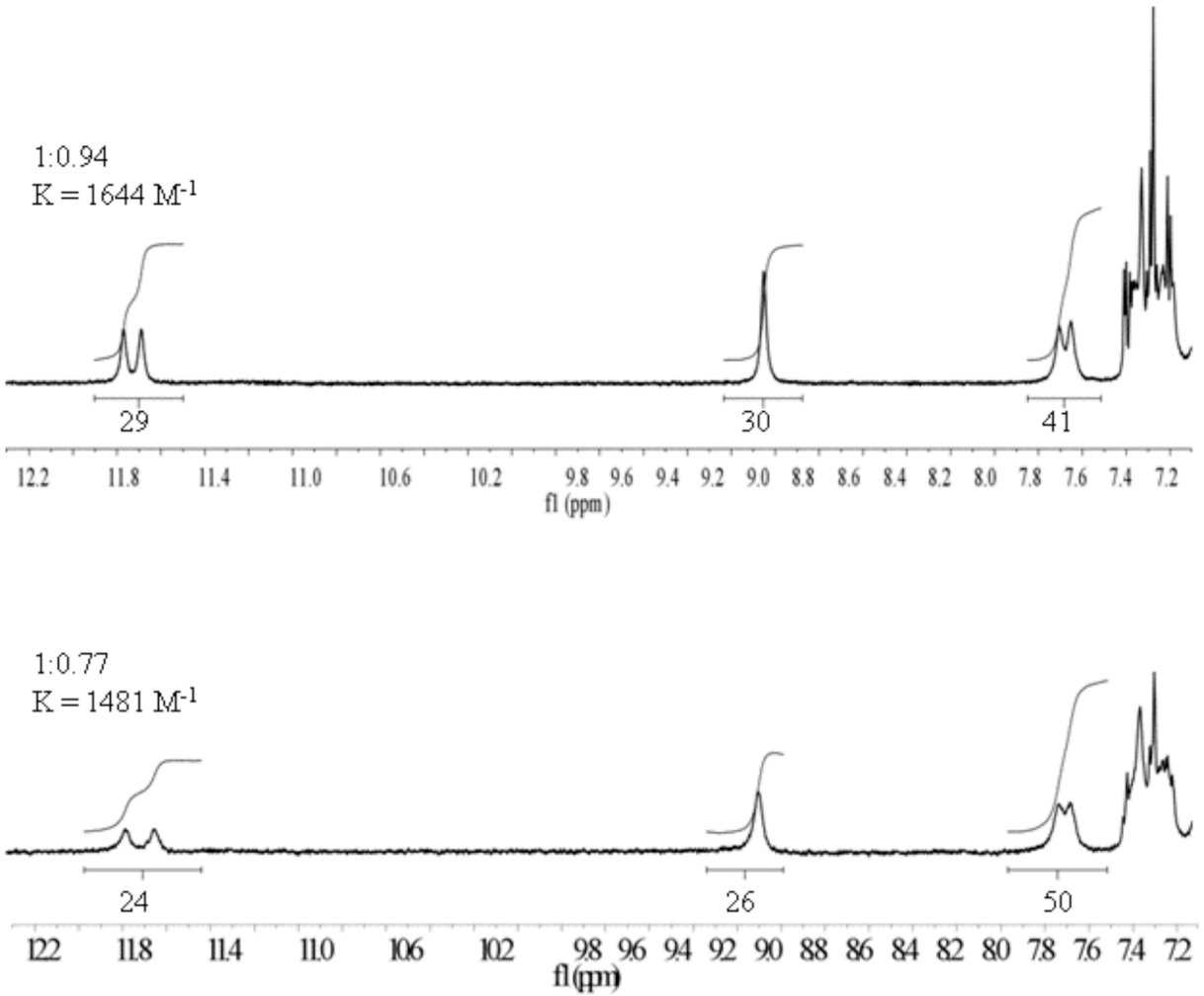



**Figure S6**. Partial $^{1}$H NMR ($CD_2Cl_2$, 500 MHz) spectra of two mixtures of free and complexed *in*/*out*-**3** and TBA[*in*/*out*-**3**·$F^-$] used for the determination of the 1:1 association constant

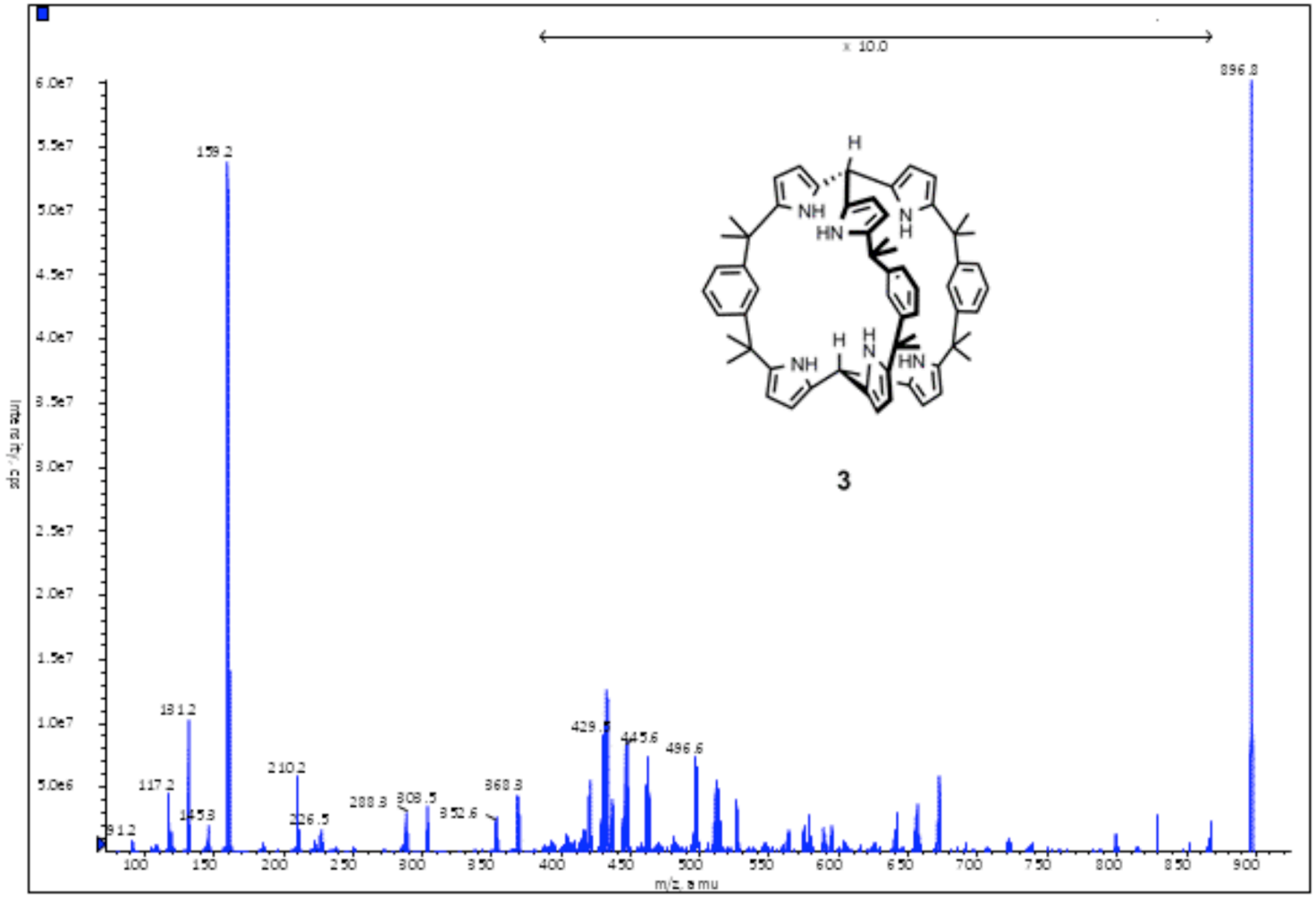



**Figure S7**. Positive ESI MS-MS of cryptand *in*/*out*-**3**.

**X-Ray Crystallography**

All six of the N–H hydrogen atoms in the structure of *in*/*out*-**3** were located from _F maps and refined freely subject to an N–H distance constraint of 0.90 Å. Two of the three included acetone solvent molecules were found to be disordered. In each case two partial occupancy orientations were identified, of *ca*. 74 and 26% occupancy for the O(80)-based molecule, and ca. 77 and 23% occupancy for the O(90)-based molecule. Only the non-hydrogen atoms of the major occupancy orientations were refined anisotropically. The methyl hydrogen atoms of the acetone molecules were added in idealised tetrahedral positions and, as they are each on an $sp^3$ centre bonded to an $sp^2$ centre, the groups were allowed to rotate about the C–C bond to find the best fit with the electron density map (the SHELXL HFIX/AFIX 137 command).

The three acetone molecules are hydrogen bonded to the N–H atoms of the pyrrole units linked to C(1). Hence, the O(70) acetone molecule is linked to the N(3)–H moiety, the O(80) acetone to N(43)–H, and the O(90) acetone to N(48)–H. The N···O, H···O distances (Å) and N–H···O angles (°) for the full or major occupancy orientations of the acetone molecules are 2.9303(16), 2.13 and 148 for the N(3)–H···O(70) interaction, 2.894(5), 2.08 and 151 for the N(43)–H···O(80) interaction, and 2.967(2), 2.18 and 146 for the N(48)–H···O(90) interaction respectively; the corresponding geometries for the minor occupancy acetone molecules are 2.872(13), 2.06 and 149 for the N(43)–H···O(80') interaction, and 2.998(9), 2.13 and 163 for the N(48)–H···O(90') interaction respectively.

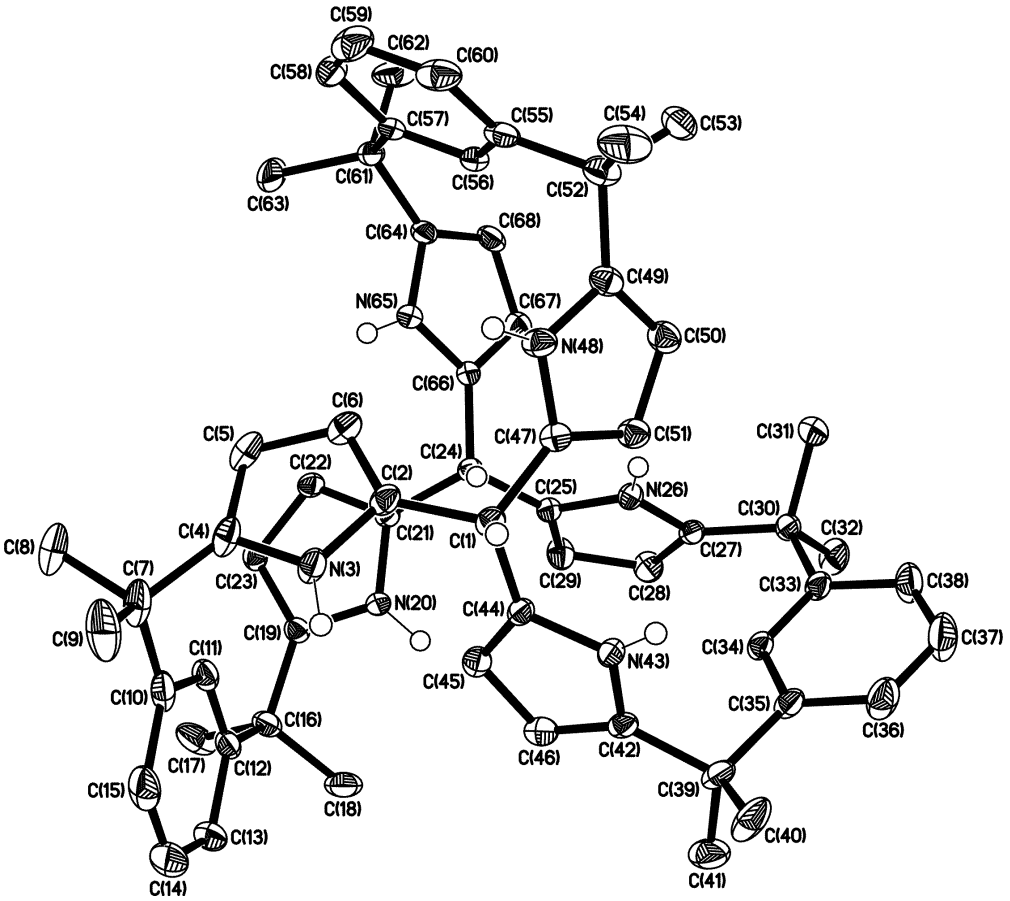
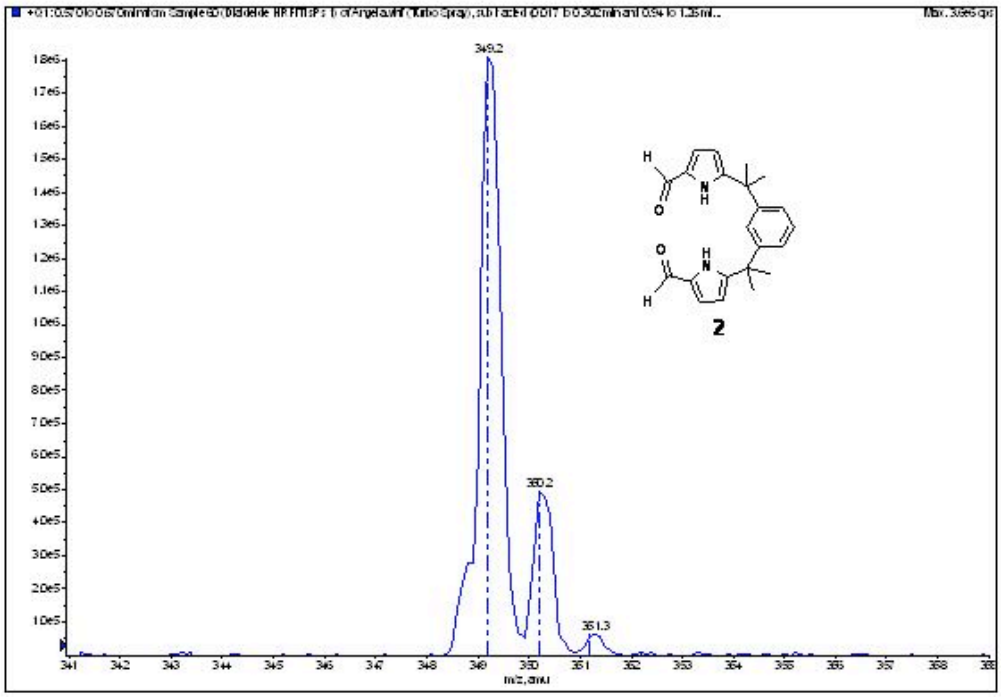



**Figure S8**. The X-Ray crystal structure of cryptand *in*/*out*-**3** showing the numbering of the atoms.

Match between measured (accurate MS-ESI) and calculated isotopic pattern for compound **2** ($C_{22}H_{24}N_2O_2$).




| Calculated for C22H24N2O2 | | | | | Measured | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| MZ | Relative_Abundance | | | | MZ | | Relative_Abundance | |
| 349,1916 | 100 | | | | 349,2 | 1,81E+06 | | |
| 350,1948 | 25,54213 | | | | 350,2 | 4,95E+05 | 27,29581 | |
| 351,1978 | 3,525478 | | | | 351,3 | 6,13E+04 | 3,380795 | |
| 352,2006 | 0,345877 | | | | | | | |
| 353,2033 | 0,026483 | | | | | | | |
| 354,206 | 0,00165 | | | | | | | |
| 355,2087 | 0,000084 | | | | | | | |
| 356,2112 | 0,000003 | | | | | | | |

Atomic coordinates (.xyz) for the Dreiding II force field minimized molecular model of the complex [*in*/*out*-**3**·F⁻]: Generated by CrystalMaker 8.0.3, (c) 1994-2008 CrystalMaker Software Limited.

| | | Fractional Coordinates | | | Orthogonal Coordinates [A] | | |
|---|---|---|---|---|---|---|---|
| Elmt | Label | x | y | z | xor | yor | zor |
| C | C1 | 1.381336 | 0.764498 | 0.836431 | 3.23219 | 21.59203 | 18.61986 |
| C | C3 | 1.397575 | 0.765425 | 0.771154 | 1.93598 | 20.89407 | 18.76582 |
| C | C6 | 1.370539 | 0.754562 | 0.666842 | 0.35141 | 19.33542 | 18.61902 |
| C | C7 | 1.464300 | 0.783531 | 0.686949 | -0.13778 | 20.36675 | 19.42222 |
| C | C9 | 1.480889 | 0.790464 | 0.751802 | 0.85009 | 21.33359 | 19.51707 |
| C | C11 | 1.314841 | 0.740342 | 0.600337 | -0.30048 | 18.01723 | 18.28689 |
| C | C12 | 1.302746 | 0.671364 | 0.597505 | -0.43826 | 17.98550 | 16.72317 |
| C | C16 | 1.377166 | 0.757388 | 0.549644 | -1.74948 | 17.88357 | 18.86299 |
| C | C20 | 1.214407 | 0.774831 | 0.584666 | 0.52344 | 16.88304 | 18.88481 |
| C | C21 | 1.123548 | 0.751515 | 0.545868 | 0.67501 | 15.62796 | 18.24057 |
| C | C23 | 1.027903 | 0.781941 | 0.531661 | 1.46483 | 14.56092 | 18.75484 |
| C | C24 | 1.026651 | 0.839437 | 0.557338 | 2.09839 | 14.78777 | 20.00271 |
| C | C26 | 1.115666 | 0.865271 | 0.593682 | 1.92983 | 15.99119 | 20.70320 |
| C | C28 | 1.208153 | 0.833564 | 0.606378 | 1.14104 | 17.01328 | 20.15626 |
| C | C30 | 0.934027 | 0.752531 | 0.490266 | 1.58259 | 13.25587 | 17.97199 |
| C | C31 | 0.955117 | 0.745244 | 0.422393 | 0.16836 | 12.58011 | 17.94729 |
| C | C35 | 0.832143 | 0.789095 | 0.482148 | 2.55880 | 12.20269 | 18.60273 |
| C | C39 | 0.914471 | 0.693268 | 0.517170 | 2.06648 | 13.52532 | 16.56859 |
| C | C42 | 0.928578 | 0.616518 | 0.582637 | 2.83724 | 14.61223 | 14.78442 |
| C | C43 | 0.854142 | 0.602077 | 0.529254 | 2.59883 | 13.29915 | 14.39189 |
| C | C45 | 0.845359 | 0.649903 | 0.488567 | 2.12034 | 12.62332 | 15.50352 |
| C | C47 | 0.968917 | 0.580925 | 0.639418 | 3.32126 | 15.75100 | 13.98534 |
| C | C49 | 0.892780 | 0.571386 | 0.678406 | 4.72535 | 15.60159 | 13.56701 |
| C | C52 | 0.821957 | 0.578673 | 0.762044 | 6.90632 | 16.04519 | 13.47182 |
| C | C53 | 0.754539 | 0.547098 | 0.715363 | 6.66371 | 14.90695 | 12.69988 |
| C | C55 | 0.798450 | 0.542550 | 0.663254 | 5.30700 | 14.62872 | 12.75857 |
| C | C57 | 0.806225 | 0.595895 | 0.826425 | 8.23660 | 16.70703 | 13.73442 |
| C | C58 | 0.800847 | 0.537162 | 0.863949 | 8.76709 | 17.23594 | 12.35543 |
| C | C62 | 0.699640 | 0.627028 | 0.820902 | 9.28821 | 15.65479 | 14.23065 |
| C | C66 | 0.889664 | 0.638863 | 0.858238 | 8.09583 | 17.77611 | 14.81403 |
| C | C67 | 0.906334 | 0.692076 | 0.826991 | 7.54652 | 17.43534 | 16.08257 |
| C | C69 | 0.983078 | 0.734160 | 0.852385 | 7.35734 | 18.36488 | 17.13849 |
| C | C70 | 1.040678 | 0.722723 | 0.914311 | 7.83322 | 19.68193 | 16.90656 |
| C | C72 | 1.027100 | 0.670923 | 0.946879 | 8.37927 | 20.06443 | 15.67382 |
| C | C74 | 0.953317 | 0.629368 | 0.918842 | 8.49466 | 19.12598 | 14.63933 |
| C | C76 | 1.000584 | 0.789978 | 0.816938 | 6.73435 | 17.97330 | 18.47300 |
| C | C77 | 0.933786 | 0.839835 | 0.837847 | 7.90992 | 17.57831 | 19.42841 |
| C | C81 | 0.966655 | 0.785827 | 0.743117 | 5.76996 | 16.73528 | 18.41933 |
| C | C85 | 1.113709 | 0.804242 | 0.831192 | 5.90726 | 19.12222 | 18.99329 |
| C | C88 | 1.281873 | 0.791568 | 0.840018 | 4.35997 | 20.72554 | 19.02605 |
| C | C89 | 1.268500 | 0.844604 | 0.869566 | 5.16745 | 20.90331 | 20.14482 |
| C | C91 | 1.163946 | 0.852730 | 0.863854 | 6.12629 | 19.90320 | 20.13028 |
| C | C93 | 1.390943 | 0.704043 | 0.862722 | 3.41338 | 22.11038 | 17.24772 |
| C | C96 | 1.369694 | 0.607156 | 0.872350 | 3.49929 | 22.20334 | 15.02350 |
| C | C97 | 1.444537 | 0.625836 | 0.924129 | 3.71848 | 23.49257 | 15.51402 |
| C | C99 | 1.458012 | 0.686026 | 0.917946 | 3.65889 | 23.43464 | 16.89662 |
| C | C101 | 1.332781 | 0.545111 | 0.854886 | 3.37266 | 21.75570 | 13.58735 |
| C | C102 | 1.214132 | 0.545597 | 0.851913 | 4.49560 | 20.67979 | 13.37028 |
| C | C106 | 1.380392 | 0.498301 | 0.905957 | 3.65133 | 22.90261 | 12.55959 |
| C | C110 | 1.363082 | 0.527182 | 0.793762 | 1.95297 | 21.26414 | 13.33279 |
| C | C111 | 1.301055 | 0.489734 | 0.748545 | 1.66486 | 20.20120 | 12.43783 |
| C | C113 | 1.325429 | 0.473439 | 0.690158 | 0.35645 | 19.69040 | 12.20432 |
| C | C114 | 1.419470 | 0.495210 | 0.678878 | -0.70462 | 20.33256 | 12.89186 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C | C116 | 1.485478 | 0.530141 | 0.723482 | -0.47416 | 21.42643 | 13.73913 |
| C | C118 | 1.457970 | 0.545244 | 0.780216 | 0.83283 | 21.89054 | 13.94218 |
| C | C120 | 1.251908 | 0.434358 | 0.643808 | 0.15732 | 18.51508 | 11.25191 |
| C | C121 | 1.248996 | 0.372136 | 0.674960 | 0.54177 | 18.98927 | 9.80877 |
| C | C125 | 1.284388 | 0.423318 | 0.579522 | -1.31829 | 17.99092 | 11.16035 |
| C | C129 | 1.146086 | 0.461516 | 0.628374 | 1.01653 | 17.34855 | 11.67486 |
| C | C132 | 1.019010 | 0.525946 | 0.625730 | 2.42139 | 16.10093 | 12.87223 |
| C | C133 | 0.976084 | 0.475780 | 0.593398 | 2.13075 | 15.39078 | 11.71151 |
| C | C135 | 1.055292 | 0.435727 | 0.595050 | 1.25549 | 16.16832 | 10.96755 |
| F | F138 | 1.158295 | 0.666904 | 0.729759 | 3.28326 | 18.42883 | 16.15135 |
| H | H2 | 1.442054 | 0.791259 | 0.865459 | 3.21868 | 22.45270 | 19.29620 |
| H | H5 | 1.271583 | 0.722060 | 0.719706 | 2.15393 | 19.20155 | 17.62214 |
| H | H8 | 1.512144 | 0.797971 | 0.659290 | -1.04974 | 20.40655 | 19.87869 |
| H | H10 | 1.542696 | 0.810601 | 0.779886 | 0.78937 | 22.20225 | 20.04861 |
| H | H13 | 1.249548 | 0.656924 | 0.626344 | 0.54722 | 17.91408 | 16.25453 |
| H | H14 | 1.376393 | 0.649549 | 0.615630 | -0.91625 | 18.89683 | 16.35302 |
| H | H15 | 1.274268 | 0.655379 | 0.549455 | -1.04281 | 17.14506 | 16.37835 |
| H | H17 | 1.450735 | 0.734248 | 0.558234 | -2.39698 | 18.67389 | 18.47667 |
| H | H18 | 1.392115 | 0.804816 | 0.550163 | -1.74525 | 17.94501 | 19.95319 |
| H | H19 | 1.334623 | 0.745642 | 0.502302 | -2.18981 | 16.92252 | 18.58453 |
| H | H22 | 1.126241 | 0.710446 | 0.527224 | 0.19939 | 15.47774 | 17.35319 |
| H | H25 | 0.961111 | 0.863990 | 0.549833 | 2.68967 | 14.07931 | 20.43482 |
| H | H27 | 1.113146 | 0.907179 | 0.610910 | 2.38157 | 16.12339 | 21.61174 |
| H | H29 | 1.271590 | 0.854187 | 0.632291 | 1.02779 | 17.86752 | 20.70497 |
| H | H32 | 0.974634 | 0.787770 | 0.404268 | -0.21249 | 12.44985 | 18.96339 |
| H | H33 | 0.887924 | 0.727978 | 0.389258 | 0.20292 | 11.59493 | 17.47669 |
| H | H34 | 1.018475 | 0.714818 | 0.422251 | -0.55241 | 13.18069 | 17.39038 |
| H | H36 | 0.839313 | 0.831754 | 0.460058 | 2.23130 | 11.91340 | 19.60330 |
| H | H37 | 0.812809 | 0.796691 | 0.527885 | 3.57054 | 12.60900 | 18.66946 |
| H | H38 | 0.767452 | 0.766044 | 0.452270 | 2.60798 | 11.29046 | 18.00287 |
| H | H41 | 1.012723 | 0.692296 | 0.604585 | 2.61640 | 15.50827 | 16.61402 |
| H | H44 | 0.813726 | 0.563570 | 0.520946 | 2.73751 | 12.90084 | 13.46268 |
| H | H46 | 0.797008 | 0.652508 | 0.445143 | 1.84905 | 11.63886 | 15.52937 |
| H | H48 | 1.029568 | 0.607421 | 0.668258 | 3.30431 | 16.60907 | 14.65588 |
| H | H51 | 0.964310 | 0.612720 | 0.760203 | 5.56914 | 17.21118 | 14.51521 |
| H | H54 | 0.684756 | 0.530450 | 0.718526 | 7.35875 | 14.36433 | 12.18611 |
| H | H56 | 0.766715 | 0.522192 | 0.621671 | 4.83424 | 13.84986 | 12.30026 |
| H | H59 | 0.784878 | 0.546215 | 0.910299 | 9.76064 | 17.67720 | 12.46049 |
| H | H60 | 0.873347 | 0.513051 | 0.870368 | 8.08937 | 17.99058 | 11.94839 |
| H | H61 | 0.740059 | 0.508017 | 0.839169 | 8.84819 | 16.43304 | 11.61950 |
| H | H63 | 0.691733 | 0.665182 | 0.789467 | 8.93322 | 15.12091 | 15.11427 |
| H | H64 | 0.690699 | 0.642219 | 0.867206 | 10.22994 | 16.14705 | 14.48695 |
| H | H65 | 0.636077 | 0.597132 | 0.802258 | 9.50149 | 14.90765 | 13.46370 |
| H | H68 | 0.860539 | 0.700024 | 0.783803 | 7.27017 | 16.46771 | 16.23269 |
| H | H71 | 1.094335 | 0.752266 | 0.936731 | 7.78269 | 20.39156 | 17.64082 |
| H | H73 | 1.071072 | 0.663460 | 0.991058 | 8.69240 | 21.02808 | 15.52958 |
| H | H75 | 0.946817 | 0.592186 | 0.944094 | 8.88721 | 19.45299 | 13.75812 |
| H | H78 | 0.943228 | 0.881522 | 0.814342 | 7.53233 | 17.29223 | 20.41371 |
| H | H79 | 0.955189 | 0.846945 | 0.888776 | 8.60788 | 18.40810 | 19.55657 |
| H | H80 | 0.852402 | 0.828133 | 0.825811 | 8.46955 | 16.73118 | 19.02440 |
| H | H82 | 0.883442 | 0.782604 | 0.726974 | 6.30162 | 15.80587 | 18.20742 |
| H | H83 | 1.001387 | 0.747187 | 0.725842 | 5.00870 | 16.87877 | 17.64705 |
| H | H84 | 0.991229 | 0.824865 | 0.720650 | 5.25283 | 16.59904 | 19.37345 |
| H | H87 | 1.174598 | 0.733321 | 0.792110 | 4.40969 | 19.26587 | 17.58079 |
| H | H90 | 1.325088 | 0.872425 | 0.891797 | 5.07944 | 21.63888 | 20.84653 |
| H | H92 | 1.130755 | 0.887616 | 0.881460 | 6.86675 | 19.78344 | 20.82107 |
| H | H95 | 1.284100 | 0.656394 | 0.799521 | 3.22408 | 20.44112 | 16.06244 |
| H | H98 | 1.483885 | 0.600090 | 0.959906 | 3.87568 | 24.33716 | 14.96350 |
| H | H100 | 1.508464 | 0.712036 | 0.948248 | 3.76686 | 24.22314 | 17.53424 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| H | H103 | 1.181224 | 0.501304 | 0.847240 | 4.60598 | 20.40303 | 12.32106 |
| H | H104 | 1.174312 | 0.572049 | 0.811840 | 4.27029 | 19.77478 | 13.94184 |
| H | H105 | 1.197359 | 0.564895 | 0.894723 | 5.46626 | 21.05217 | 13.70818 |
| H | H107 | 1.350338 | 0.454230 | 0.891986 | 3.57200 | 22.53102 | 11.53420 |
| H | H108 | 1.362082 | 0.508723 | 0.951410 | 4.65653 | 23.30970 | 12.69200 |
| H | H109 | 1.463835 | 0.496579 | 0.912376 | 2.93291 | 23.71707 | 12.67515 |
| H | H112 | 1.234677 | 0.473793 | 0.757938 | 2.43702 | 19.76723 | 11.93762 |
| H | H115 | 1.442375 | 0.485848 | 0.638144 | -1.66973 | 20.02455 | 12.78541 |
| H | H117 | 1.553614 | 0.544625 | 0.714608 | -1.25905 | 21.88477 | 14.20942 |
| H | H119 | 1.508631 | 0.570150 | 0.811746 | 0.95681 | 22.69841 | 14.55374 |
| H | H122 | 1.216375 | 0.374521 | 0.716826 | 1.60170 | 19.23808 | 9.73840 |
| H | H123 | 1.326469 | 0.353898 | 0.689073 | -0.03324 | 19.87679 | 9.53193 |
| H | H124 | 1.202648 | 0.340871 | 0.642486 | 0.33951 | 18.21715 | 9.06466 |
| H | H126 | 1.289056 | 0.465049 | 0.555025 | -1.66584 | 17.65033 | 12.13871 |
| H | H127 | 1.229205 | 0.395188 | 0.548134 | -1.40481 | 17.15051 | 10.46757 |
| H | H128 | 1.358905 | 0.401326 | 0.586979 | -1.99146 | 18.77313 | 10.80321 |
| H | H131 | 1.168650 | 0.544316 | 0.667974 | 1.73369 | 17.92191 | 13.51585 |
| H | H134 | 0.900694 | 0.469112 | 0.572678 | 2.49482 | 14.47644 | 11.44436 |
| H | H136 | 1.047791 | 0.394481 | 0.575557 | 0.86534 | 15.91838 | 10.05747 |
| N | N4 | 1.334932 | 0.743434 | 0.719328 | 1.58533 | 19.71615 | 18.22511 |
| N | N40 | 0.961088 | 0.671232 | 0.573905 | 2.52845 | 14.69667 | 16.08534 |
| N | N50 | 0.904249 | 0.591258 | 0.737689 | 5.70573 | 16.43144 | 13.94946 |
| N | N86 | 1.187692 | 0.769709 | 0.816607 | 4.81714 | 19.63673 | 18.38591 |
| N | N94 | 1.338291 | 0.655953 | 0.837847 | 3.35525 | 21.40768 | 16.10376 |
| N | N130 | 1.120072 | 0.515965 | 0.644658 | 1.72196 | 17.24324 | 12.81951 |