Supporting Information

Rapid Dissolution of $BaSO_4$ by Macropa, an Eighteen-Membered Macrocycle with High Affinity for Ba^{2+}

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1. EXPERIMENTAL PROCEDURES

1.1 Materials and Instruments

All solvents and reagents, unless otherwise noted, were of ACS grade or higher and were purchased from commercial sources. Solvents noted as dry were obtained following storage over new 3 Å molecular sieves. $N(CH_3)_4OH$ was purchased as a 25 wt% solution in H_2O (trace metals basis, Beantown Chemical, Hudson, NH). Concentrated hydrochloric acid was of trace metals grade (BDH Aristar Plus, VWR, Radnor, PA). Metal salts were purchased from Strem Chemicals (Newburyport, MA) and were of the highest purity available. Inductively coupled plasma (ICP) standard solutions of metal ions in dilute HNO_3 were purchased from VWR (BDH Aristar; 998 μg/mL calcium in 0.1% v/v HNO_3, 1005 μg/mL strontium in 0.1% v/v HNO_3, 1001 μg/mL barium in 0.1% v/v HNO_3, and 10023 μg/mL barium in 2% v/v HNO_3). Deionized water (≥18 MΩ-cm) was obtained from an Elga Purelab Flex 2 water purification system and used in all experiments. 1,7,10,16-tetraoxa-4,13-diazacyclooctadecane (4,13-diaza-18-crown-6) was either purchased from EMD Millipore (Darmstadt, Germany) or synthesized as described previously.[1] $H_4DOTA•6H_2O$ was purchased from Macrocyclics, Inc. (Plano, TX). Hydroxyapatite (HAP) was of high resolution grade (Calbiochem, Behring Diagnostics, La Jolla, CA).

The high-performance liquid chromatography (HPLC) system used for the analysis and purification of compounds consisted of a CBM-20A communications bus module, an LC-20AP (preparative) or LC-20AT (analytical) pump, and an SPD-20AV UV/vis detector monitoring at 270 nm (Shimadzu, Japan). Analytical chromatography was carried out using an Ultra Aqueous C18 column, 100 Å, 5 μm, 250 mm x 4.6 mm (Restek, Bellefonte, PA) at a flow rate of 1.0 mL/min. Semi-preparative purification was performed using an Epic Polar preparative column, 120 Å, 10 μm, 25 cm x 20 mm (ES Industries, West Berlin, NJ) at a flow rate of 14 mL/min. Solvent A was 0.1% trifluoroacetic acid (TFA) in H_2O; solvent B was 0.1% TFA in CH_3OH; solvent C was 0.1%

TFA in CH_3CN. The following gradient HPLC methods were employed: method A, 10% B (0–5 min), 10–100% B (5–25 min); method B: 10% C (0–10 min), 10–100% C (10–30 min).

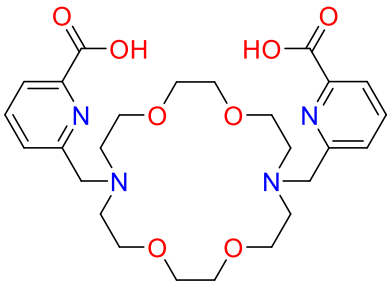
NMR spectra were recorded at 25 °C on a Varian Inova 600 MHz spectrometer or on a Bruker AV III HD 500 MHz spectrometer equipped with a broadband Prodigy cryoprobe. Chemical shifts are reported in ppm. ^{1}H and ^{13}C NMR spectra were referenced to the TMS internal standard (0 ppm) or to the residual solvent peak. The splitting of proton resonances in the reported ^{1}H spectra is defined as: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = doublet of doublets, td = triplet of doublets, and br = broad. Quantitative ^{1}H NMR spectra were acquired using a 90 ° pulse width and a 30 sec relaxation delay; presaturation of the H_2O peak was applied as necessary.

High-resolution mass spectra (HRMS) were obtained on an Exactive Orbitrap mass spectrometer in either positive electrospray ionization (ESI) mode or direct analysis in real time (DART) mode (ThermoFisher Scientific, Waltham, MA). UV/visible spectra were recorded on a Cary 8454 UV-Vis (Agilent Technologies, Santa Clara, CA) using 1-cm quartz cuvettes. Elemental analysis (EA) was performed by Atlantic Microlab, Inc. (Norcross, GA). Graphite furnace atomic absorption spectroscopy (GFAAS) was carried out on a PinAAcle 900Z spectrometer (PerkinElmer, Waltham, MA) equipped with an AS900 autosampler and a barium hollow cathode lamp.

1.2 Synthesis and Characterization of Ligands and Barium Complexes

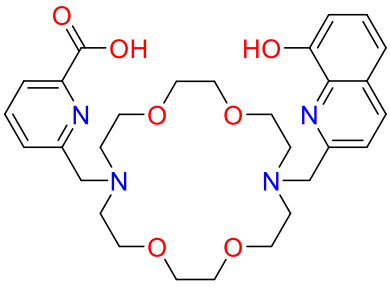
Caution! Although we have experienced no difficulties with the perchlorate salts, these should be regarded as potentially explosive and handled with care.[2]

Macropa (6,6'-((1,4,10,13-tetraoxa-7,16-diazacyclooctadecane-7,16-diyl)bis(methylene))dipicolinic acid). The ligand was prepared according to the literature procedure[3,4] and isolated as a $2HCl•4H_2O$ salt. Elemental analysis found: C, 46.27, 46.43; H, 6.75, 6.67; N, 8.25, 8.07. Calc. for $C_{26}H_{36}N_4O_8•2HCl•4H_2O$: C, 46.09; H, 6.84; N, 8.27.



macropa

Macropaquin (6-((16-((8-hydroxyquinolin-2-yl)methyl)-1,4,10,13-tetraoxa-7,16-diazacyclooctadecan-7-yl)methyl)picolinic acid). To a pale-yellow solution of methyl 6-((1,4,10,13-tetraoxa-7,16-diazacyclooctadecan-7-yl)methyl)picolinate•2TFA•$1H_2O$[5] (0.6119 g, 0.93 mmol) in dry 1,2-dichloroethane (23 mL) was sequentially added diisopropylethylamine (405 µL, 2.23 mmol), 8-hydroxyquinoline-2-carbaldehyde[6] (0.2446 g, 1.41 mmol), and $NaBH(OAc)_3$ (0.3932 g, 1.86 mmol). The flask was equipped with a drying tube, and the yellow-orange suspension was stirred at RT. After 18 h, the pale-yellow suspension was quenched with acetone (6 mL) and concentrated at 35 °C under reduced pressure to yield a cloudy, pale-yellow oil containing white precipitate. ESI-MS *m/z:* 569.29739; calcd for $[M + H]^+$, 569.29698.

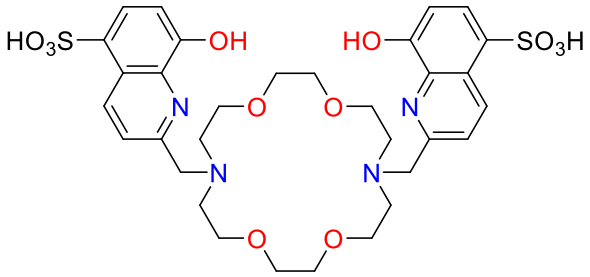


macropaquin

The crude oil was dissolved in 6 M HCl (16 mL), and the resulting bright-yellow solution was heated at 90 °C overnight. The solvent was removed under reduced pressure at 60 °C, and the yellow residue was taken up in 10% CH_3CN/H_2O containing 0.1% TFA (6 mL). The slight

suspension was filtered, and the filtrate was purified by reverse-phase preparative HPLC using method B. Pure fractions were combined and concentrated at 60 °C under reduced pressure. To prepare the hydrochloride salt, the residue was thrice redissolved in 6 M HCl (3 mL each) and concentrated under reduced pressure. The product was then twice redissolved in H_2O (3 mL each) and concentrated to remove any excess acid. Lyophilization afforded the title compound as a bright-yellow solid (0.3685 g, 57% overall yield). Batch to batch variation was observed in the number of chloride counteranions per ligand; both trihydrochloride and tetrahydrochloride salts were isolated, as confirmed by potentiometric titration (below) and elemental analysis. No differences were observed in the data obtained from either salt form. ^{1}H NMR (500 MHz, DMSO-d_6) δ= 11.18 (br m, 2H), 10.14 (br s, 1H), 8.43 (d, J = 8.5 Hz, 1H), 8.14 (t, J = 7.6 Hz, 1H), 8.10 (dd, J = 7.8, 1.1 Hz, 1H), 7.93 (dd, J = 7.5, 1.2 Hz, 1H), 7.64 (d, J = 8.5 Hz, 1H), 7.50 (t, J = 7.8 Hz, 1H), 7.45 (dd, J = 8.2, 1.3 Hz, 1H), 7.15 (dd, J = 7.5, 1.3 Hz, 1H), 4.96 (s, 2H), 4.77 (s, 2H), 3.93 (m, 8H), 3.61–3.53 (m, 16H). ^{13}C{^{1}H} NMR (126 MHz, DMSO-d_6) δ 165.35, 153,15, 151.03, 149.89, 147.23, 139.29, 137.71, 136.65, 128.13, 127.97, 127.95, 124.29, 120.72, 117.56, 111.95, 69.17, 64.76, 64.63, 57.84, 56.68, 54.20, 53.48. Only 22 distinct signals are detected in the spectrum. Two carbons most likely comprise the signal at 69.17 ppm. ^{19}F NMR (470 MHz, DMSO-d_6): no peaks, confirming the absence of TFA. Elemental analysis found: C, 49.57; H, 6.23; N, 7.94. Calc. for $C_{29}H_{38}N_4O_7$•3HCl•2H_2O: C, 49.76; H, 6.48; N, 8.00. HPLC t_R = 19.166 min (Method A). DART-MS *m/z:* 555.28091; calcd for $[M + H]^+$, 555.28133.

Macroquin–SO_3 (2,2'-((1,4,10,13-tetraoxa-7,16-diazacyclooctadecane-7,16-diyl)bis(methylene))bis(8-hydroxyquinoline-5-sulfonic acid)). The ligand was synthesized



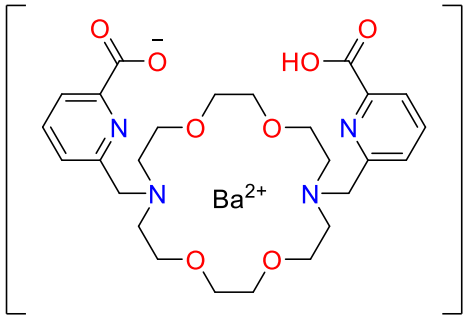
macroquin-SO_3

using a modified literature procedure.[7] To an orange solution of 4,13-diaza-18-crown-6 (0.6611 g, 2.52 mmol) and 8-hydroxyquinoline-2-carbaldehyde[6] (0.959 g, 5.54 mmol) in dry 1,2-dichloroethane (50 mL) was added $NaBH(OAc)_3$ (1.609 g, 7.59 mmol). The flask was fitted with a drying tube, and the orange suspension was stirred at RT. After 19 h, saturated $NaHCO_3$ (20 mL) was added to the pale-yellow suspension to quench the reaction, and the mixture was extracted with $CHCl_3$ (100 mL). The organic layer was concentrated on the rotary evaporator at 40 °C to give an orange oil (1.4958 g), which was used without further purification.

To the crude oil at 0 °C was slowly added chlorosulfonic acid (10 mL). The resulting orange solution was removed from the ice bath, stirred at RT for 2 h 40 min, and carefully poured into an Erlenmeyer flask (250 mL) filled with crushed ice over the course of 7 min. The bright-yellow slurry was stirred overnight and then concentrated at 60 °C on the rotary evaporator to a yellow-orange liquid. The pH of the liquid was adjusted to approximately 12 using a combination of concentrated aqueous NaOH (2 M) and NaOH pellets, and then filtered through a nylon membrane (0.22 μm). The yellow-orange filtrate (~100 mL) was acidified with concentrated (37%) HCl to pH 1–2. The resulting suspension was centrifuged, and the pellet was washed twice with 1 M HCl to furnish an off-white solid. The solid was then recrystallized twice by dissolving it in aq. NaOH (2 M) and acidifying to pH 1–2 with concentrated HCl to induce reprecipitation. Each time, the suspension was centrifuged and the pellets were washed with cold H_2O. Lyophilization of the

isolated solid provided macroquin–SO_3 as a pale-yellow powder (0.6032 g, 30% overall yield). ^{1}H NMR (500 MHz, DMSO-d_6) δ= 9.93 and 9.89 (2 overlapping br s, 2H), 9.24 (d, J = 8.8 Hz, 1H), 7.88 (d, J = 8.0 Hz, 1H), 7.65 (d, J = 8.8 Hz, 1H), 7.07 (d, J = 8.0 Hz, 1H), 4.93 (s, 2H), 3.87 (br t, J = 4.8 Hz, 4H), 3.65 (br t, J = 4.9 Hz, 4H), 3.45 (s, 4H). ^{13}C{^{1}H} NMR (126 MHz, DMSO-d_6) δ 153.20, 149.28, 137.90, 136.44, 135.18, 126.39, 124.44, 120.41, 109.62, 69.21, 64.76, 57.85, 54.34. Elemental analysis found: C, 47.95; H, 5.66; N, 6.99; Cl, 0.81. Calc for $C_{32}H_{40}N_4O_{12}S_2$•$3H_2O$•0.2HCl: C, 48.16; H, 5.83; N, 7.02; Cl, 0.89. HPLC t_R = 14.660 (Method A). ESI-MS *m/z:* 737.21652; calcd for $[M + H]^+$, 737.21569.

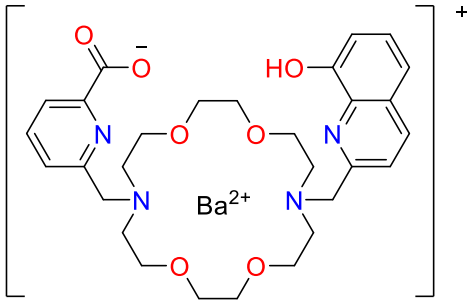
[Ba(Hmacropa)]ClO$_4$. To a suspension of macropa•2HCl•$4H_2O$ (0.0230 g, 0.034 mmol) in 2-propanol (0.7 mL) was added triethylamine (20.2 µL, 0.145 mmol). The colorless solution was heated at reflux for 25 min before a solution of $Ba(ClO_4)_2$•$3H_2O$ (0.0150 g, 0.038 mmol) in 2-propanol (0.65 mL) was added dropwise. A precipitate formed immediately. The white suspension was stirred at reflux for 1 h before it was cooled and centrifuged. The supernatant was removed, and the pellet was washed with 2-propanol (2 × 0.2 mL) and air-dried on glassine paper. The title complex was isolated as a white powder (0.0206 g) containing a minor amount of residual triethylamine salt and 2-propanol. ^{1}H NMR (600 MHz, CD_3OD basified with 2 M NaOH to pD/H ~11 by litmus) δ= 7.70 (td, J = 7.6, 1.0 Hz, 2H), 7.64 (d, J = 7.7 Hz, 2H), 7.31 (d, J = 7.6 Hz, 2H), 5.23 (d, J = 14.4 Hz, 2H), 4.65 (t, J = 11.0 Hz, 2H), 3.98 (q, J = 11.5 Hz, 4H), 3.90 (t, J = 10.6 Hz, 2H), 3.53–3.48 (m, 4H), 3.44 (d, J = 10.0 Hz, 2H), 3.35–3.28 (m, 4H partially overlapping with CD_3OD peak), 3.24 (d, J = 10.6 Hz, 2H), 2.69 (td, J = 13.8, 3.2 Hz, 2H), 2.44 (d, J = 14.0 Hz, 2H), 2.15 (d, J = 13.8 Hz, 2H). ^{13}C{^{1}H} NMR (126 MHz, CD_3OD basified with 2 M



[Ba(Hmacropa)]$^+$

NaOH to pD/H ~11 by litmus) δ= 172.12, 159.07, 154.70, 138.92, 125.73, 123.12, 71.73, 71.40, 69.17, 68.87, 61.20, 56.13, 55.83. ESI-MS *m/z:* 669.15166 and 335.07930; calcd for $[C_{26}H_{35}BaN_4O_8]^+$ and $[C_{26}H_{36}BaN_4O_8]^{2+}$, respectively: 669.15018 and 335.07873.

[Ba(Hmacropaquin)]ClO₄. To a suspension of macropaquin•4.2HCl•1.5H_2O (0.096 g, 0.131 mmol) in 2-propanol (2 mL) was added triethylamine (109.2 µL, 0.784 mmol). The suspension was heated at reflux for 25 min, giving a pale-yellow solution to which a solution of $Ba(ClO_4)_2$•3H_2O (0.0541 g, 0.139 mmol) in 2-propanol (1.5 mL) was added dropwise. A precipitate formed immediately. The yellow-brown suspension was stirred at reflux for 1.5 h and then it was cooled, divided into three portions, and centrifuged. The supernatant was removed, and each pellet was washed with 2-propanol (2 × 0.350 mL), combined, and dried under reduced pressure to give the title complex as a pale-tan powder (0.0640 g) containing residual triethylamine salt and 2-propanol. ^{1}H NMR (600 MHz, CD_3OD basified with 2 M NaOH to pD/H ~ 11 by litmus) δ= 7.86 (d, J = 8.4 Hz, 1H), 7.49 (t, J = 7.7 Hz, 1H), 7.28 (d, J = 7.8 Hz, 1H), 7.22 (d, J = 7.7 Hz, 1H), 7.10 (d, J = 8.4 Hz, 1H), 6.84 (t, J = 7.8 Hz, 1H), 6.51 (d, J = 7.8 Hz, 1H), 6.24 (d, J = 7.9 Hz, 1H), 5.12 (d, J = 14.4 Hz, 1H), 5.00 (d, J = 15.8 Hz, 1H), 4.59 (t, J = 10.2 Hz, 1H), 4.53 (t, J = 10.7 Hz, 1H), 4.15 (t, J = 10.2 Hz, 1H), 4.05 (t, J = 11.0 Hz, 1H), 3.98–3.88 (m, 3H), 3.85 (t, J = 10.4 Hz, 1H), 3.70–3.58 (m, 2H), 3.57–3.49 (m, 4H), 3.49–3.39 (m, 3H), 3.39–3.31 (m, 2H), 3.29–3.17 (m, 2H), 2.81–2.72 (m, 1H), 2.68 (d, J = 13.9 Hz, 1H), 2.48 (d, J = 13.9 Hz, 1H), 2.22 (d, J = 13.4 Hz, 1H), 2.17 (d, J = 13.6 Hz, 1H). ^{13}C{^{1}H} NMR (126 MHz, CD_3OD basified with 2 M NaOH to pD/H ~ 11 by litmus) δ= 171.67, 167.04, 158.12, 154.60, 154.09, 143.77, 138.75, 138.11, 130.31, 129.23, 125.14, 122.70, 120.09, 114.58, 110.14, 71.93, 71.71, 71.55, 69.93, 69.66, 69.52, 62.15,



[Ba(Hmacropaquin)]⁺

61.56, 55.56, 55.50, 55.36, 54.14. Only 27 distinct signals are detected in the spectrum. Two carbons most likely comprise each signal at 71.71 ppm and 69.66 ppm. ESI-MS *m/z:* 691.17227 and 346.08969; calcd for $[C_{29}H_{37}BaN_4O_7]^+$ and $[C_{29}H_{38}BaN_4O_7]^{2+}$, respectively: 691.17092 and 346.08910.

1.3 X-ray Diffraction Studies

Crystals of [Ba(Hmacropa)(DMF)]ClO_4•Et_2O were grown via vapor diffusion of Et_2O into a DMF solution of the isolated complex at 4 °C. After 10 days, the inner vial was removed, capped, and stored at 4 °C for 2 months to produce single crystals suitable for X-ray diffraction. Single crystals of [Ba(Hmacropaquin)(DMF)]ClO_4•DMF were obtained following vapor diffusion of petroleum ether into a DMF solution of the isolated complex. Single crystals of [Ba(H_2macroquin-SO_3)(H_2O)]•4H_2O were isolated from a capped solution of ligand (99.2 μM) and $BaNO_3$ (99.2 μM, from ICP standard) in 10 mM MOPS buffer (pH 7.4, I = 100 mM NMe_4Cl) after 2 days.

Low-temperature X-ray diffraction data for crystals of [Ba(Hmacropaquin)(DMF)]ClO_4 and [Ba(H_2macroquin–SO_3)(H_2O)]•4H_2O were collected on a Rigaku XtaLAB Synergy diffractometer coupled to a Rigaku Hypix detector with Cu Kα radiation (λ = 1.54184 Å), from a PhotonJet micro-focus X-ray source at 100 K. The diffraction images were processed and scaled using the CrysAlisPro software (2015, Rigaku OD, The Woodlands, TX). Low-temperature X-ray diffraction data for [Ba(Hmacropa)(DMF)]ClO_4•Et_2O were collected on a Bruker APEX 2 CCD Kappa diffractometer (Mo Kα, λ = 0.71073 Å) at 223 K. The diffraction images were processed and scaled using the APEX2 software (2012, Bruker AXS Inc., Madison, Wisconsin). [Ba(Hmacropa)(DMF)]ClO_4•Et_2O crystallizes as a racemic twin [BASF = 0.406(14)]. The structures were solved through intrinsic phasing using SHELXT[8] and refined against F^2 on all data by full-matrix least squares with SHELXL[9] following established refinement strategies.[10] All non-

hydrogen atoms were refined anisotropically. All hydrogen atoms bound to carbon were included in the model at geometrically calculated positions and refined using a riding model. Hydrogen atoms bound to oxygen were located in the difference Fourier synthesis and subsequently refined semi-freely with the help of distance restraints. The isotropic displacement parameters of all hydrogen atoms were fixed to 1.2 times the Ueq value of the atoms they are linked to (1.5 times for methyl groups). Crystallographic data collection and refinement parameters, bond lengths, and bond angles are collected in Tables S1–4.

1.4 Thermodynamic Stability Studies by Potentiometric Titration

1.4.1 General

Potentiometric measurements were carried out using a Metrohm Titrando 888 titrator equipped with a Ross Orion combination electrode (8103BN, ThermoFisher Scientific) and a Metrohm 806 exchange unit with an automatic burette (10 mL). The titration vessel was fitted with a removable glass cell (~70 mL) and was thermostated at 25 °C using a Thermomix 1442D circulating water bath. CO_2 was excluded from the vessel prior to and during the titrations using a small positive pressure of Ar that was passed through a solution of 30 wt% KOH. Carbonate-free KOH (~0.1 M) was prepared by dissolving KOH pellets (semiconductor grade, 99.99% trace metals basis, Sigma-Aldrich) in freshly boiled water (≥18 MΩ-cm) and was standardized by potentiometric titration against potassium hydrogen phthalate. Hydrochloric acid (0.1 M, J.T. Baker) was standardized against freshly prepared KOH. Titration solutions were maintained at a constant ionic strength of 0.1 M using KCl (BioUltra, ≥99.5%, Sigma-Aldrich) and were equilibrated for 15 minutes prior to the addition of titrant. Before every titration, the electrode was calibrated in terms of hydrogen ion concentration by titrating a solution of standardized HCl (5 mM) containing supporting electrolyte (95 mM) with standardized KOH (2 mL). Data within the

pH ranges of 2.5–3.2 and 10.8–11.2 were analyzed using the program *Glee* (v. 3.0.21)[11] to obtain the standard electrode potential (E_0) and slope factor. Owing to the sharp rise in pH at the titration endpoint (pH 3.2–10.8), data obtained in this region are subject to significant error and were therefore excluded from the calibration analysis. A pK_w value of 13.78 was taken from the literature.[12]

1.4.2 Protonation constants

Stock solutions of macropa and macropaquin were prepared in H_2O. A stock solution of macroquin–SO_3 could not be prepared due to the poor aqueous solubility of this ligand; instead, a weighed portion of macroquin–SO_3 was used for each titration. The exact ligand concentrations were determined from the potentiometric titration curves with KOH. Protonation equilibria of macropa^{2-} and macropaquin^{2-} were determined by adding standardized KOH to a solution (20 mL) containing ligand (~0.02 mmol), 0.1 M HCl (0.1 mmol), and 1 M KCl (1.9 mmol). The titration method employed a 0.1 mV/min drift limit with a maximum wait time of 90 sec between addition of base and measurement. At least 70 data points were collected over the pH range of 2.5–10.5 (macropa) or 2.5–11.3 (macropaquin). The protonation constants, defined in Eq. 1, were calculated from the average of at least 4 independent titrations using the program *Hyperquad2013*.[13] Both ligand and proton concentrations were admitted as refineable parameters. The errors given for the protonation constants correspond to one standard deviation. The protonation constants measured for macropa^{2-} were consistent with those previously reported;[4] log K_{a5} was not able to be determined under the conditions employed here. Protonation equilibria of macroquin–SO_3^{4-} were determined by titrating standardized HCl (~5.19 mL) into a solution (62.5 mL) containing ligand (~0.013 mmol, 10.4 mg), KOH (0.25 mmol), and 1 M KCl (6 mmol). The same titration method was employed as described above for the other two ligands. At least 90 data points over the pH

range of 4.0–10.8 were included in the refinement; no additional protonation constants could be refined when data from pH 2.5–3.99 were included. The protonation constants were calculated from the average of 15 independent titrations.

$$K_{ai} = \frac{[H_iL]}{[H_{i-1}L][H^+]} \quad (1)$$

1.4.3 Stability constants

ICP standards of calcium, strontium, and barium in dilute HNO_3 were employed in the titrations. The exact amount of HNO_3 was determined by potentiometric titration of each metal solution (1 mL), diluted to a known volume with H_2O, with standardized KOH to pH ~7; under these conditions, no precipitation of metal hydroxide species was observed. The data were analyzed using a Gran plot.[14] Stability constants were measured for the alkaline earth complexes of macropa^{2-} and macropaquin^{2-} by adding standardized KOH to a solution (20 mL) containing ligand (0.02 mmol), metal (0.02 mmol), 1 M KCl (1.9 mmol), and a portion of 0.1 M HCl sufficient to bring the total acid content (HCl + HNO_3) to 0.1 mmol. The titration method employed either a 0.1 mV/min or 0.2 mV/min drift limit with a maximum wait time of 300 sec between addition of base and measurement. Implementing a minimum wait time (e.g. 60 sec) did not change the values of the calculated stability constants. Data points (~30–90) obtained over the pH ranges of 2.5–10.5 (Ba–macropa), 2.8–10.5 (Sr–macropa), 4.0–10.5 (Ca–macropa), 2.7–11.3 (Ba–macropaquin), and 4.0–11.3 (Sr– and Ca–macropaquin) were included in the refinements. These pH ranges reflect the portion of the titration curves in which metal binding is occurring. Using the protonation constants measured for each ligand, the stability constants (Eq. 2–4) were calculated from the average of at least 3 independent titrations using *Hyperquad2013*. Proton concentration was admitted as a refineable parameter. Ligand concentration was taken as the averaged value obtained from the

refinements of ligand-only titrations. The errors given for the stability constants correspond to one standard deviation.

$$K_{ML} = \frac{[ML]}{[M][L]} \quad (2)$$

$$K_{MHL} = \frac{[MHL]}{[ML][H]} \quad (3)$$

$$K_{MH_2L} = \frac{[MH_2L]}{[MHL][H]} \quad (4)$$

The alkaline earth stability constants for macroquin–SO_3^{4-} were determined using a system in which each ligand titration was paired with a ligand–metal titration. These pairwise titrations enabled the ligand concentration for the metal–ligand titrations to be known with reasonable certainty from the refinement of the ligand-only titrations. Immediately following a titration of the free ligand with HCl, metal ion (0.013 mmol) was added and the solution was equilibrated under Ar for 15 min before the addition of standardized KOH. The same titration method was employed as described above for macropa^{2-} and macropaquin^{2-}. Approximately 80–100 data points over the pH ranges of 3.5–10.5 (Ba), 4–10.5 (Sr), and 6–10.5 (Ca) were included in the refinements. Stability constants were calculated as described above. Although the inclusion of a CaH_2L species in the model for the macroquin–SO_3 titrations with Ca^{2+} resulted in reduced sigma values and lower residuals, the refined concentration of this species was deemed insufficient (<10%) for the accurate determination of log K_{CaH2L}. Owing to the very low concentrations of metal and macroquin–SO_3 employed in these titrations, the error associated with the calculated stability constants may be slightly higher than is reflected by the standard deviations of the measurements.

Log conditional constants (log K′) of the alkaline earth complexes at pH 7.4 were calculated in *HySS 2008* using the experimentally determined protonation and stability constants. These constants are expressed by the following equation:

$$K' = \frac{[(ML)']}{[M][H_nL]}$$

In this equation, [(ML)′] = [ML] + [MHL] + [MH_2L], and [H_nL] = [L], [HL], [H_2L]…[H_nL].

1.5 Complex Stability: Transmetalation Challenges

1.5.1 La^{3+} transmetalation studies

The pH of a 100 mM 3-(*N*-morpholino)propanesulfonic acid (MOPS) buffer (I = 1 M NMe_4Cl) was adjusted to 7.3 using aqueous NMe_4OH. A stock solution of $LaCl_3$•$6.8H_2O$ (310 mM) was made fresh daily in 5 mM HCl. Stock solutions of macropa (28.88 mM) and macropaquin (18.53 mM) were prepared in H_2O. A stock solution of macroquin–SO_3 (7.39 mM) was prepared in MOPS buffer by adding aqueous NMe_4OH dropwise until all solid was dissolved.

Stock solutions of complexes were prepared in situ in MOPS buffer using equimolar (59 μM) ligand and $Ba(NO_3)_2$ (1001 μg/mL ICP standard) and were equilibrated for at least 5 minutes prior to use. Transmetalation challenges were initiated by adding 478 μL (1000-fold excess) of $LaCl_3$ to a cuvette containing 2522 μL of Ba–L complex. The cuvette was inverted 3x, and then UV-vis spectra were acquired every 15 or 30 sec until there were no further spectral changes (20–90 min). The final pH of each solution was between 7.23 and 7.36. Pseudo first-order rate constants (k_{obs}) were calculated from the slopes of the plots of $\ln(A_\infty - A_t)$ versus time for each complex using linear regression. A_∞ is the final absorbance value and A_t is the absorbance value at time *t* at 284 nm, 264 nm, or 368 nm, wavelengths corresponding to the appearance of the La^{3+} complexes of macropa, macropaquin, and macroquin–SO_3, respectively. Half-lives ($t_{1/2}$) were calculated using the equation $t_{1/2} = 0.693/k_{obs}$ and are reported as the mean of three replicates ± 1 standard deviation. In control experiments, a solution containing Ba–L (2522 μL) and 5 mM HCl (478 μL) was monitored for 20–90 min by UV-vis spectrophotometry. No spectral changes were observed for

any of the complexes under these conditions, confirming that the Ba–L complexes do not undergo dissociation over the time course of the experiments.

1.5.2 Hydroxyapatite challenges

Hydroxyapatite (HAP, $Ca_5(PO_4)_3(OH)$) challenges were carried out in 500 mM Tris buffer. The pH of the buffer was adjusted to 7.6 using concentrated HCl. Stock solutions of macropa (19.34 mM) and macropaquin (19.00 mM) were prepared in water. The concentrations of these stocks were verified by quantitative NMR (n = 2 for each ligand) using 2 independently prepared standards of potassium hydrogen phthalate in D_2O. Macroquin–SO_3 (14.3 mg) was suspended in water, and sufficient aqueous NMe_4OH was added to dissolve the solid. The concentration of macroquin–SO_3 was determined by UV-vis spectrophotometry from the average of two titrations with Ba^{2+}. Two independent titrants containing Ba^{2+} (final concentration of 1.67 mM, using 1001 μg/mL ICP standard) and macroquin–SO_3 (18 μL of stock solution) were prepared in Tris buffer to a final volume of 3000 μL. Aliquots (10 or 20 μL) of titrant were added by pipette to a cuvette containing ligand (18 μL of stock solution) and Tris buffer (2982 μL). The absorbance at 320 nm was monitored until spectral changes ceased, at which point $[Ba^{2+}] = [L]$. From the volume of titrant added, the concentration of the stock solution of macroquin–SO_3 was calculated to be 8.17 mM, which was within 9% of the theoretical value of 8.96 mM based on mass.

Three independent solutions of each complex were prepared containing ligand (276.29–277.20 μM, 1.1 equiv) and Ba^{2+} (1.0 equiv, from 1001 μg/mL ICP standard) in Tris buffer. Three independent positive control solutions were prepared in the same manner, except an aliquot of water was used in place of ligand. HAP challenges were initiated by adding an aliquot (20 μL) of the complex or control solution to a suspension of HAP (50 ± 1 mg) in Tris (1980 μL). The final concentrations of ligand and Ba^{2+} were 2.8 μM and 2.5 μM, respectively. The quantity of

suspended HAP corresponds to a 20,000-fold molar excess compared to the concentration of Ba–L complex. The suspensions were stirred at room temperature (22 ± 1 °C) using identical stir bars (10 x 3 mm) and a stir rate of 550 ppm. A piece of cardboard was placed beneath each vial to minimize the transfer of heat from the stir plate. At time points of 10 min, 1 h, 5 h, and 20 h, each suspension was allowed to settle for approximately 1 min. An aliquot (~1 mL) was removed and immediately centrifuged for 5 min (25 °C, 15,000 RPM), and then a portion of supernatant was carefully transferred into a separate tube and analyzed as described below. Challenges were carried out in triplicate for each time point, except for the 5 h HAP challenge for Ba–macropa, which was performed in duplicate.

The supernatants were diluted 4-fold with water and analyzed for barium content by GFAAS using THGA graphite tubes with end caps (PerkinElmer, Part No. B3000655), a wavelength of 553.6 nm, and a slit width of 0.2 nm. With the lamp used in this study, the lamp energy was typically 73 and the lamp current was set to 25 mA. Signals were processed in the background-corrected peak area mode. Autosampler cups were made of polypropylene. Significant ligand-dependent matrix effects were observed during method development. Therefore, for each Ba–L complex studied, calibration standards containing both ligand (2.8 μM) and barium (2.5 μM) were prepared in Tris buffer to match the conditions of the challenges. Each standard was diluted 4-fold with water to give a solution containing ~0.7 μM of ligand and ~0.625 μM (86 μg/L) of barium, which was used to construct the ligand-specific calibration curve. All calibrations consisted of 4 concentrations (21.5–86 μg/L) and were linear through zero (correlation coefficient >0.995). Water was employed as the diluent. The furance method is provided in the table below:

Parameters	Temperature (°C)	Ramp (s)	Hold (s)	Ar gas flow (mL/min)
Dry	110	1	30	250
Dry	130	15	30	250
Pyrolize	1200	10	20	250
Atomize	2550	0	10	0
Clean	2600	1	15	250

Each sample was analyzed in triplicate and averaged. Between each sample, a single measurement of water was made to prevent barium carryover into the next sample measurement. After every 5 samples were analyzed, an independently prepared Ba–L calibration standard (86 μg/L of Ba) was analyzed a maximum of 2 times as a quality control check. If the second measurement was not within ±10% of the known concentration of barium, the instrument was re-calibrated and the data between the failed calibration check and the previous calibration check was excluded. Data from each time point were averaged and the results are reported as the percentage of barium remaining in the liquid phase, reflecting intact Ba–L complex. The errors provided correspond to 1 standard deviation.

1.6 Barium Sulfate Dissolution Studies

1.6.1 Dissolution of Barium Sulfate

$BaSO_4$ dissolution experiments at pH 8 were performed in $NaHCO_3$ (1 M, pH = 7.9–8.0); dissolution studies at pH 11 were performed in Na_2CO_3 (1 M, pH adjusted to 10.98 using concentrated HCl). Stock solutions of macropa (19.34 mM for pH 8 studies and 21.84 mM for pH 11 studies), macropaquin (19.00 mM), DTPA (21.04 mM for pH 8 studies and 18.37 mM for pH 11 studies), and DOTA (19.94 mM) were all prepared in water. The concentrations of the macropa, macropaquin, and DTPA stocks were determined by quantitative NMR (n = 2 for each ligand) using 2 independently prepared standards of potassium hydrogen phthalate in D_2O. The concentration of the DOTA stock solution was calculated from the mass of the ligand used (255.5

mg). A solution of Na_2SO_4 (293 mM) was prepared in water. The barium source for this experiment was an ICP standard solution of $Ba(NO_3)_2$ (72.99 mM; 10023 μg/mL) in 2% v/v HNO_3.

Dissolution studies were carried out in 2 mL borosilicate vials equipped with identical magnetic stir bars (6.4 x 3 mm). Each $BaSO_4$ suspension was prepared independently by mixing $Ba(NO_3)_2$ and Na_2SO_4 in 1 M $NaHCO_3$ or Na_2CO_3 to give final concentrations of 4.53 mM (621,426 μg/L) and 13.48 mM, respectively. Dissolution was initiated by the addition of an aliquot of ligand (5 mM final concentration, 1.1 equiv with respect to Ba^{2+}) to each suspension. Controls (pH 8) received an aliquot of water instead of ligand. The suspensions were stirred at room temperature (22 ± 1 °C) at a rate of 550 RPM. At time points of 5 min (pH 11 only), 10 min, 20 min, and 30 min, the suspensions were filtered through nylon syringe filters (either 0.2 μm, Fisherbrand or 0.22 μm, EZ Flow, Foxx Life Sciences), and the filtrates were analyzed as described below. The dissolution experiments were performed in triplicate at every time point for each ligand except DOTA, for which 6 replicates were run for 20 min and 30 min time points at pH 8.

The filtered samples were diluted 6565-fold (65x101) with water and analyzed for barium content by GFAAS using the furnace method and instrument paramaters given in Section 1.5.2. Due to matrix effects from the ligands, calibrations were carried out in a manner similar to that described in Section 1.5.2. Standards containing both ligand and barium at the same concentrations employed in the dissolution studies were prepared in either $NaHCO_3$ (pH 8) or Na_2CO_3 (pH 11); water was substituted for Na_2SO_4. Each standard was diluted 6565-fold with water to give a solution containing 762 nM of ligand and 690 nM (95 μg/L) of barium, which was used to construct the ligand-specific calibration curve. All calibrations consisted of 4 concentrations (23.8–95 μg/L) and were linear through zero (correlation coefficient >0.995). Water was used as the diluent. Following calibration, each sample was analyzed in triplicate and averaged. After the analysis of

every 3 samples, a single measurement of water was made to ensure that there was no carryover of barium. After every 3 (pH 11) or 6 (pH 8) samples were analyzed, an independently-prepared Ba–L standard was analyzed a maximum of 2 times as a quality control check. If the measurement was not within ±10% of the known concentration of barium, the instrument was re-calibrated and the data between the failed calibration check and the previous calibration check was excluded. Data from each time point were averaged and the results are reported as the percentage of barium dissolved. The errors given correspond to 1 standard deviation.

1.6.2 Dissolution of Barite Ore

A sample of barite crude ore (ExBar W) from China was provided by Excalibar Minerals (Katy, TX). The rocks (approximately 1–3 inch pieces) were crushed using a hammer, and barite particles between 0.5 and 2 mm were isolated using a set of sieves (American Educational 3070-6 Screen Sieves Set, Amazon.com). The barite was washed with deionized water and absolute ethanol to remove the fines, dried in an oven at 110 °C, and then cooled in a dessicator.

Barite dissolution studies were carried out at pH 8 and pH 11. Ligands were dissolved in water and the pH of these solutions was adjusted with 2 M NaOH. The ligand concentrations (45.68–48.84 mM) were determined by quantitative NMR (n = 2 for each ligand) using 2 independently prepared standards of potassium hydrogen phthalate in D_2O. Control solutions were prepared by adjusting the pH of 48 mM aqueous NaCl to either pH 8 or pH 11 using dilute NaOH and HCl. To simulate a pipeline clogged with $BaSO_4$ scale, polypropylene columns (Bio-Rad Poly-Prep chromatography columns, 2 mL bed volume) were filled with barite (3.00 g ± 0.01 g). Ligand or control solution (1 mL) was loaded onto each column by removing the column endcap until the liquid reached the bed support. After a soak time of 1 h, the solution was eluted using a small positive pressure of air and filtered through a 0.22 μm nylon syringe filter (EZ Flow, Foxx Life

Sciences). The filtrate was diluted 2,020–51,005-fold with water and analyzed for barium content by GFAAS using the method described below. The barite dissolution experiments were performed in triplicate for both ligands at each pH.

Calibration solutions containing both ligand (48–49 mM) and barium (48 mM) were prepared to a final volume of 2 mL using an ICP standard solution of barium (72.99 mM; 10023 μg/mL), pH 8 ligand solution (161.38 mM macropa, 157.05 mM DTPA), and water. The calibration solution for the controls was prepared in a similar manner, except pH 8 NaCl solution (150.4 mM) was used instead of ligand solution. Each standard was diluted 101x101x5-fold with water to give a solution containing 0.94 μM (129.2 μg/L) of barium, which was used to construct the ligand-specific calibration curve. All calibrations consisted of 4 concentrations (32.3–129.2 μg/L) and were linear through zero (correlation coefficient >0.995). Water was employed as the diluent. The furnace method is provided in the table below:

Parameters	Temperature (°C)	Ramp (s)	Hold (s)	Ar gas flow (mL/min)
Dry	110	1	20	250
Dry	140	10	5	250
Pyrolize	700	10	20	250
Atomize	2300	0	8	0
Clean	2500	1	10	250

Each sample was analyzed in triplicate and averaged. Between each sample, a single measurement of water was made to prevent barium carryover into the next sample measurement. After every 3 samples were analyzed, an independently prepared Ba–L calibration standard (129.2 μg/L of Ba) was analyzed a maximum of 2 times as a quality control check. If the second measurement was not within ±10% of the known concentration of barium, the instrument was re-calibrated and the data between the failed calibration check and the previous calibration check was

excluded. Data for each set of triplicate samples were averaged and the results are reported in terms of ligand efficiency (%):

$$Ligand\ Efficiency\ = \frac{Ba_{exp}}{Ba_{max}} \times 100$$

In the equation, Ba_{exp} is the concentration of barium (μg/L) measured in the liquid eluted from the column and Ba_{max} is the maximum concentration of barium (μg/L) that can be chelated by each ligand upon dissolution of $BaSO_4$, calculated from the exact concentration of each ligand solution used and assuming a 1:1 M:L binding model. For example, macropa at a concentration of 48.84 mM can dissolve a maximum amount of 48.84 mM $BaSO_4$, equaling 6,707,197 μg/L barium. If a concentration of 3,353,598 μg/L of barium is measured in the eluted sample by GFAAS, the ligand efficiency is 50%, indicating that 50% of the ligand solution complexed barium. The errors provided correspond to 1 standard deviation. No barium was detected in the control experiments at pH 8 and pH 11.

1.6.3 Recovery and Reuse of Macropa

The capacity for ligand recycling from a solution of macropa-dissolved $BaSO_4$ was assessed qualitatively. An initial solution of macropa-dissolved $BaSO_4$ was prepared by stirring at 450 RPM a suspension containing $BaSO_4$ (8.74 mM $Ba(NO_3)_2$; 26.04 mM Na_2SO_4), macropa (9.66 mM), and 2M NaOH (35 μL) in 1M $NaHCO_3$ (326 μL). The final volume was 1035 μL and the pH was 8. After 17 min, a clear and colorless solution was observed, reflecting the complete dissolution of $BaSO_4$. The solution was adjusted to pH 1 (by litmus paper) by adding concentrated HCl (3 drops). The resultant suspension was stirred for 10 min and then filtered through a nylon syringe filter (0.22 μm, EZ Flow, Foxx Life Sciences). The syringe filter was rinsed with 0.1 M HCl (2 x 100 μL) to facilitate full recovery of the ligand. The pH of the filtrate was carefully adjusted back to pH 8 (by litmus paper) with 2 M NaOH. To this recovered solution of macropa

was added another portion of $BaSO_4$ (0.009 mmol $BaNO_3$, 0.027 mmol Na_2SO_4). The suspension was stirred at 450 RPM and RT. The dissolution of $BaSO_4$ was monitored visually until all of the $BaSO_4$ was dissolved, marking the completion of a full cycle of ligand recovery and reuse. Another cycle was then initiated via the addition of concentrated HCl to the solution. A total of 5 cycles were performed and the time to full dissolution of $BaSO_4$ was recorded. Despite the marginal amount of precipitate that persisted after an extended period of stirring during the 4th and 5th cycles, dissolution of most of the $BaSO_4$ was rapidly achieved within the first hour. The precipitate may be attributed to a small amount of $BaSO_4$ that remains undissolved as a consequence of ligand loss over time, which occurs because aliquots of the solution are removed to assess the pH during the recovery and reuse process.

2. SUPPORTING FIGURES AND TABLES

2.1 Characterization of Ligands and Barium Complexes

2.1.1 NMR Spectra

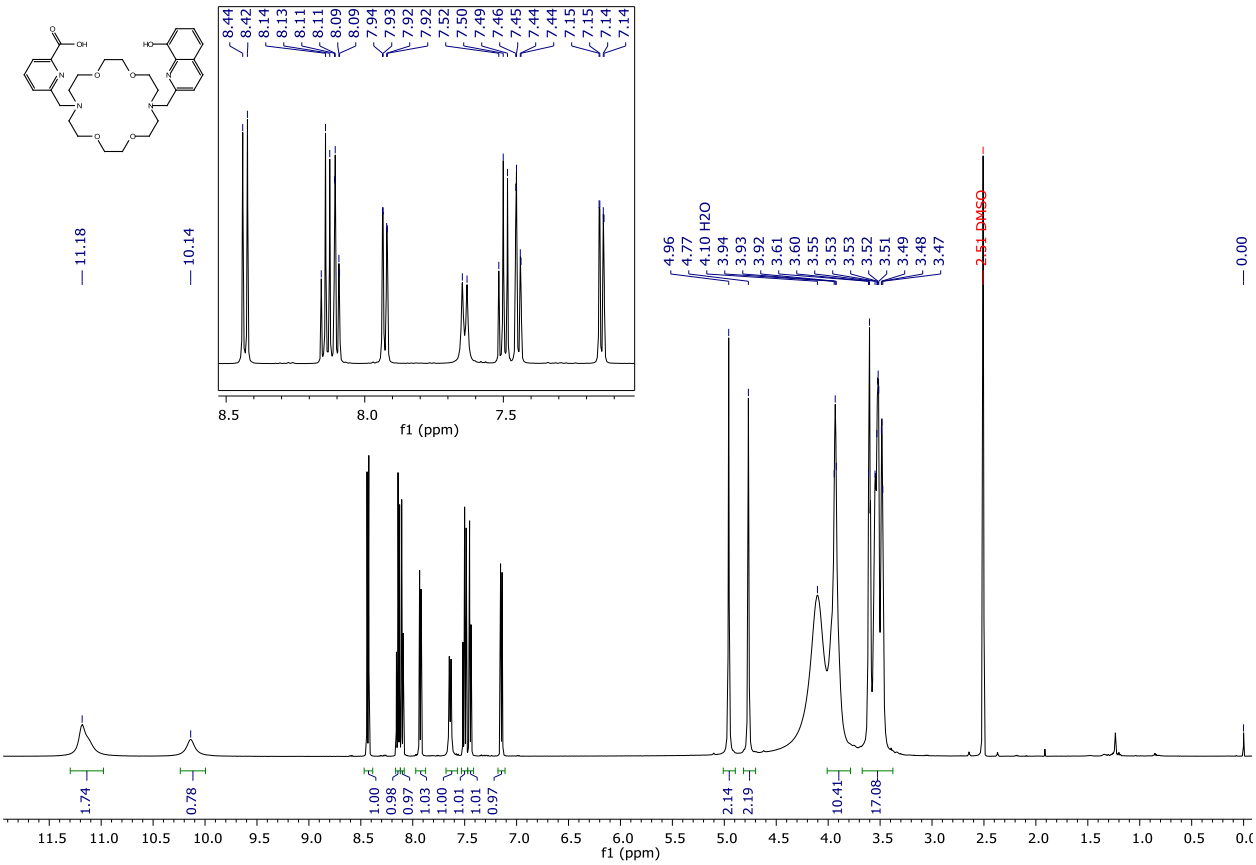


Figure S1. ^{1}H NMR spectrum of macropaquin. 500 MHz, DMSO-d_6. The peak at 1.23 ppm is a minor unidentified hydrocarbon impurity.

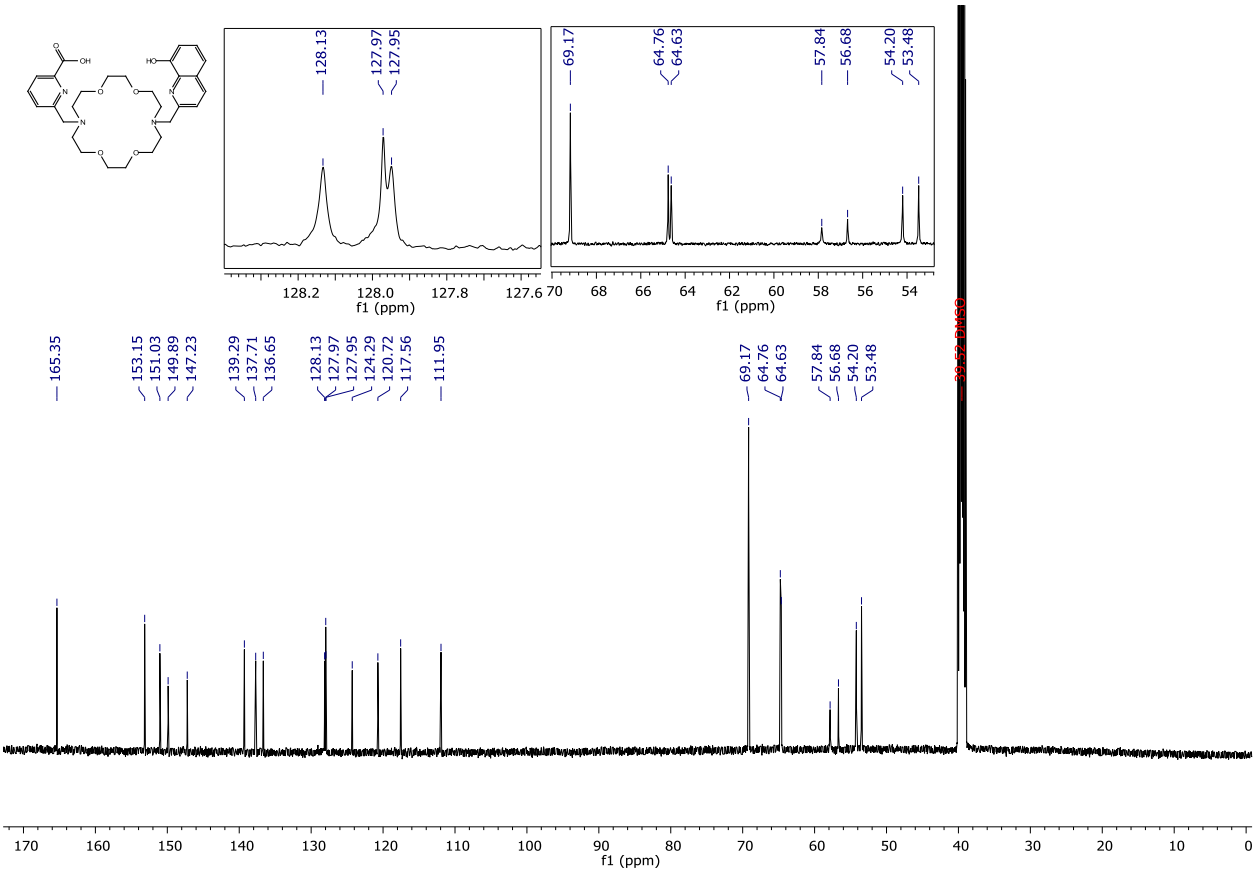


Figure S2. $^{13}C\{^{1}H\}$ NMR spectrum of macropaquin. 126 MHz, DMSO-d_6. Only 22 distinct signals are detected in the spectrum. Two carbons most likely comprise the signal at 69.17 ppm.

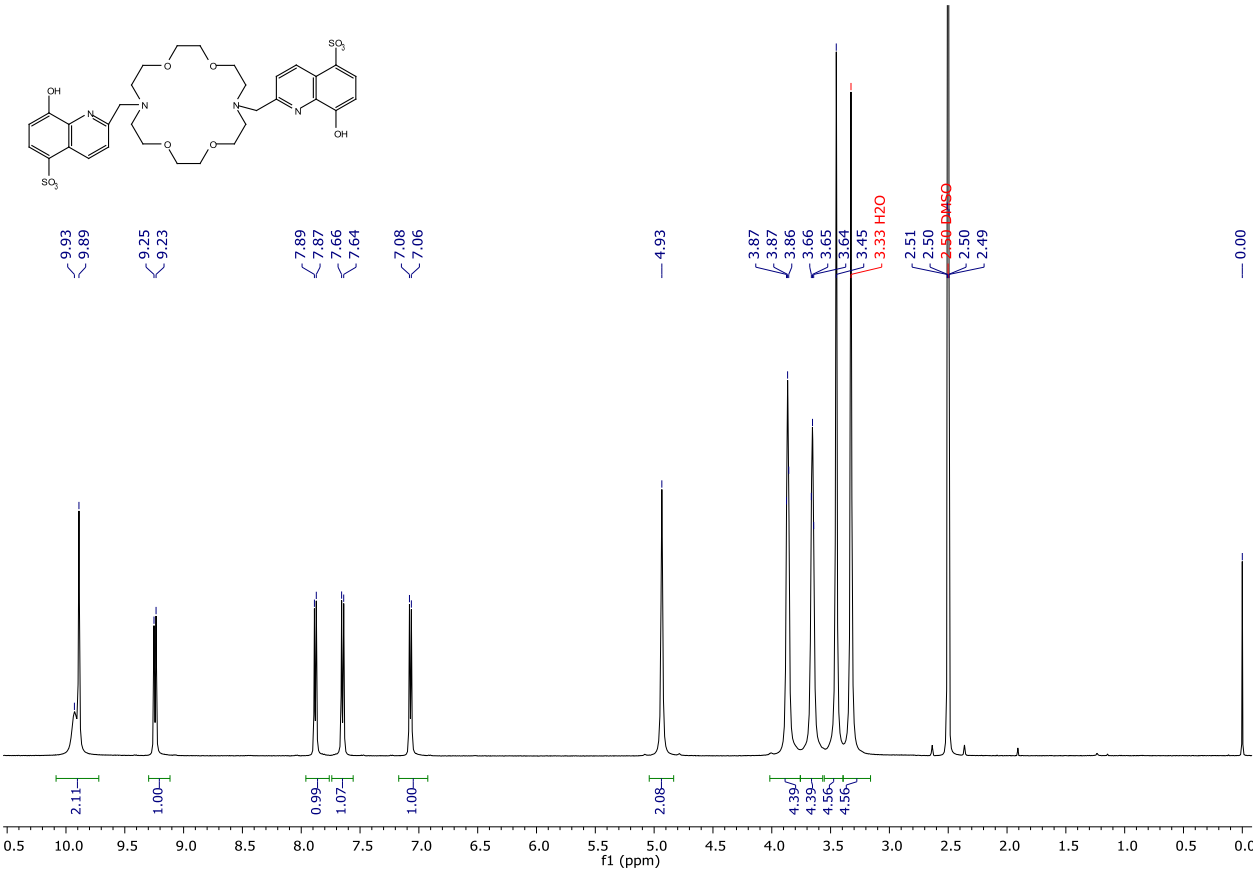


Figure S3. ^{1}H NMR spectrum of macroquin-SO_3. 500 MHz, DMSO-d_6.

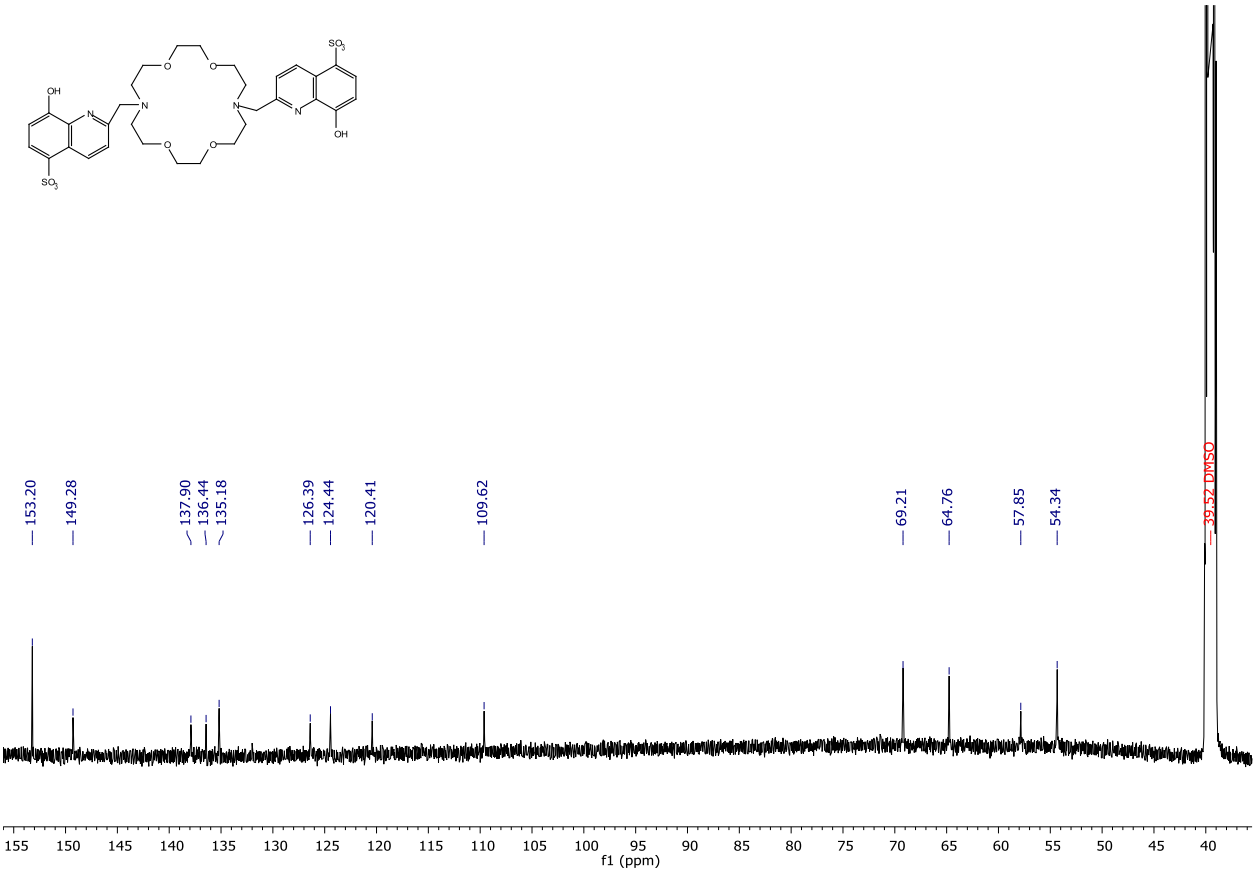


Figure S4. $^{13}C\{^{1}H\}$ NMR spectrum of macroquin-SO_3. 126 MHz, DMSO-d_6.

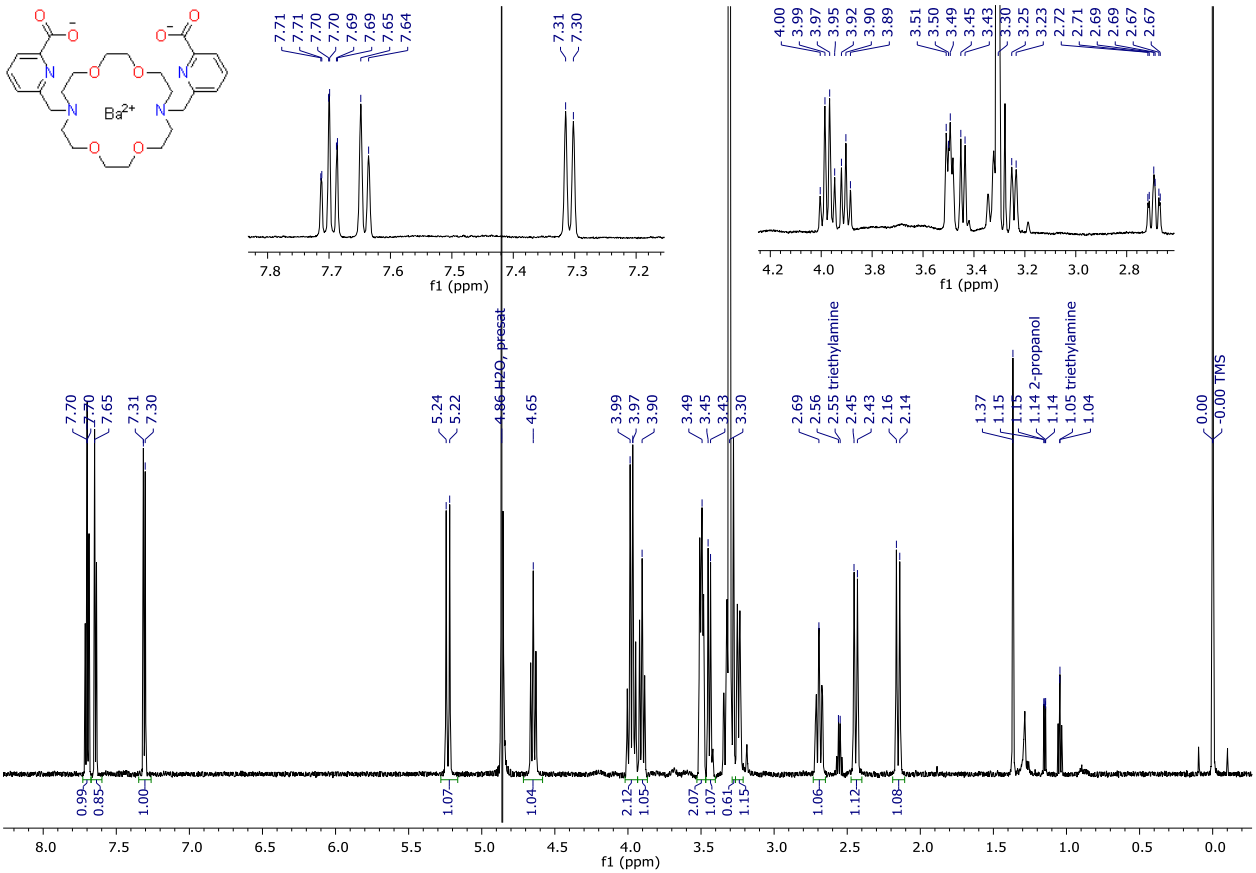


Figure S5. ^{1}H NMR spectrum of Ba–macropa. 600 MHz, CD_3OD basified with 2 M NaOH to pH/D ~11 by litmus paper.

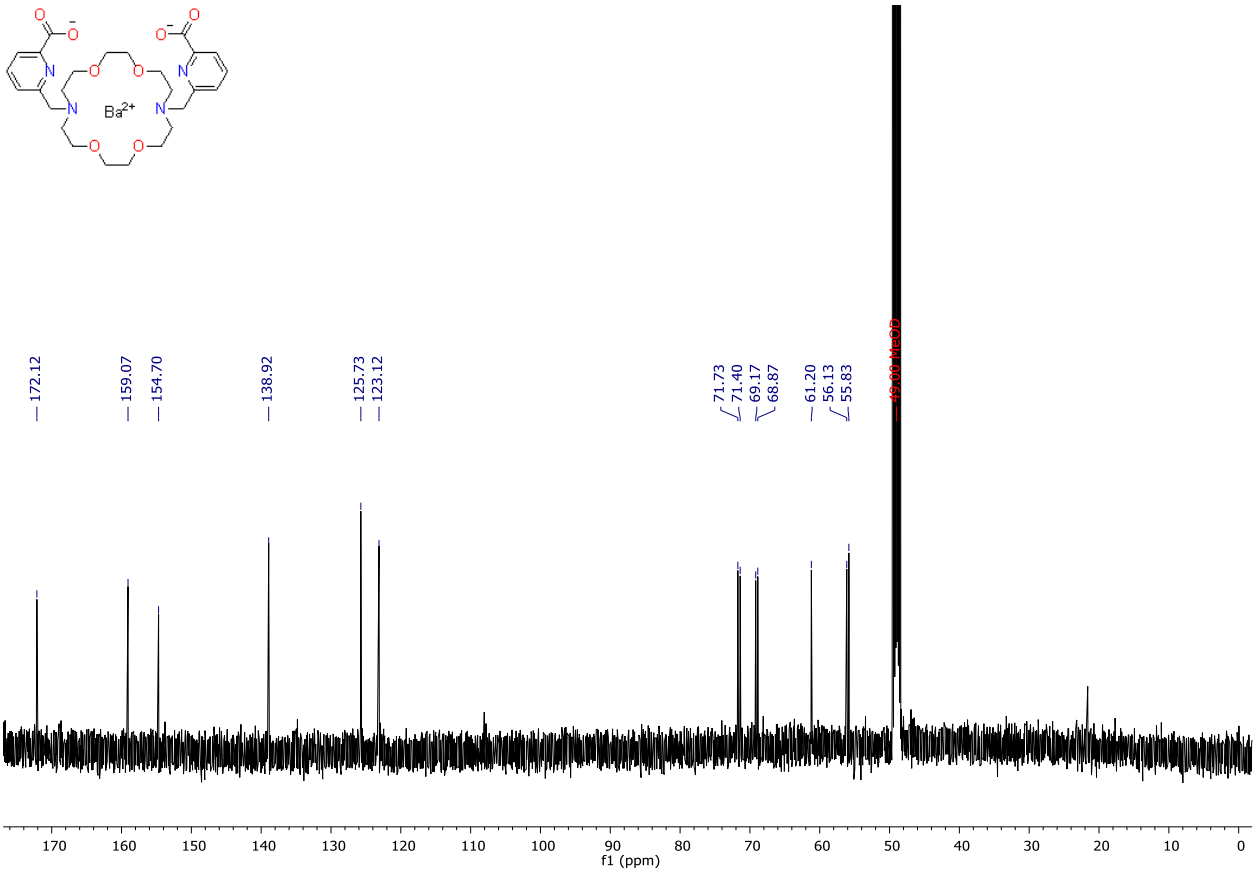


Figure S6. $^{13}C\{^{1}H\}$ NMR spectrum of Ba–macropa. 126 MHz, CD_3OD basified with 2 M NaOH to pH/D ~11 by litmus paper.

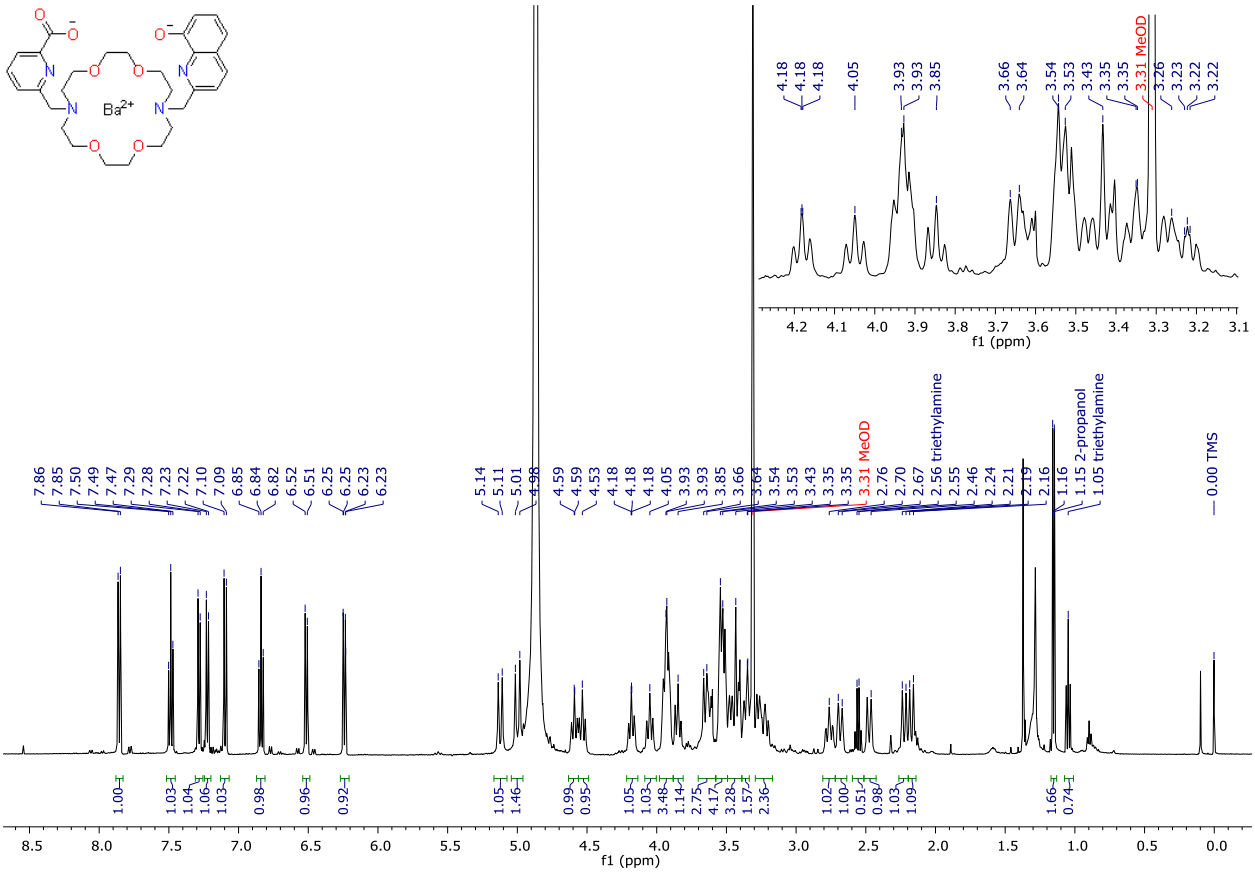


Figure S7. ^{1}H NMR spectrum of Ba–macropaquin. 500 MHz, CD_3OD basified with 2 M NaOH to pH/D ~11 by litmus paper. The minor aromatic peaks do not match those of the free ligand. Based on this observation, we believe that they may arise from a minor conformational isomer of the complex in solution.

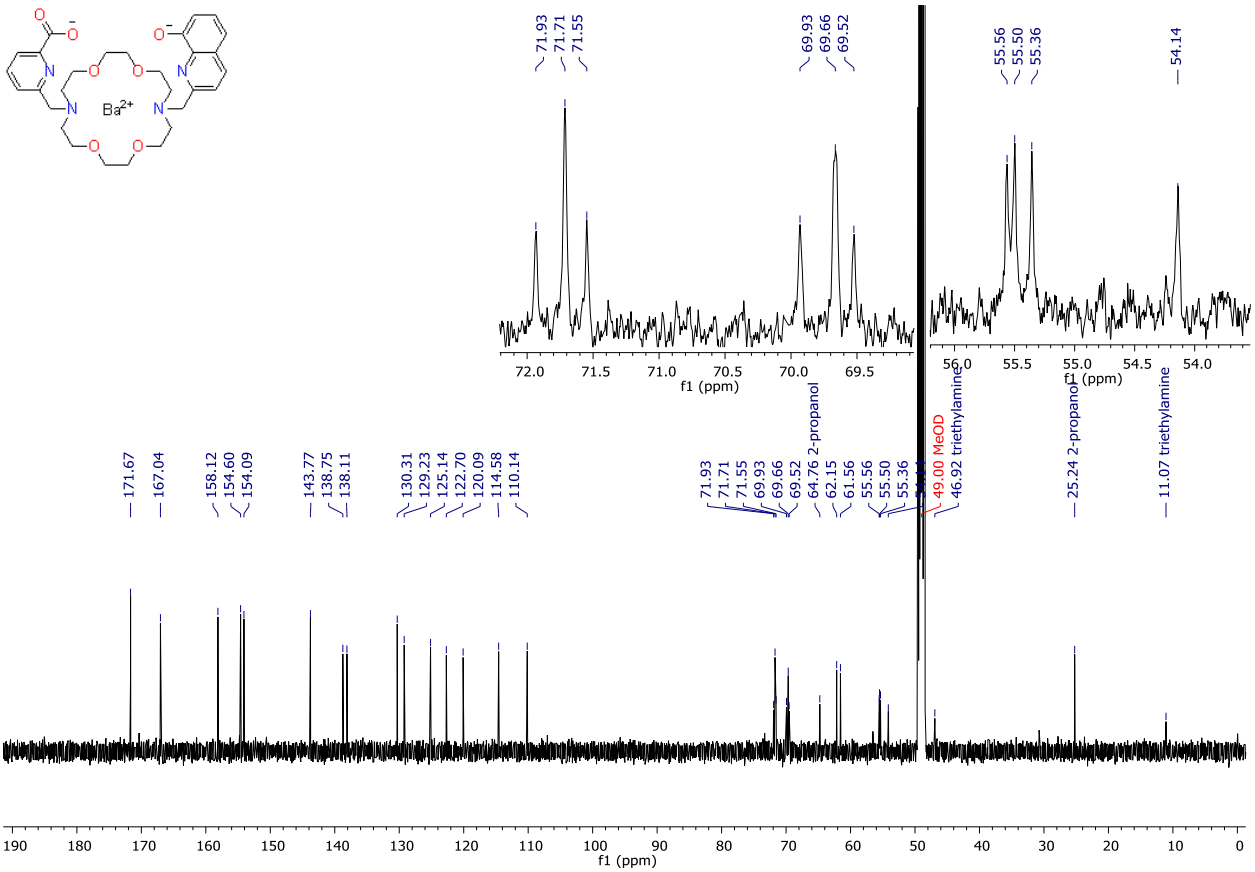


Figure S8. $^{13}C\{^{1}H\}$ NMR spectrum of Ba–macropaquin. 126 MHz, CD_3OD basified with 2 M NaOH to pH/D ~11 by litmus paper. Two carbons most likely comprise each signal at 71.71 ppm and 69.66 ppm.

2.1.2 HPLC Chromatograms

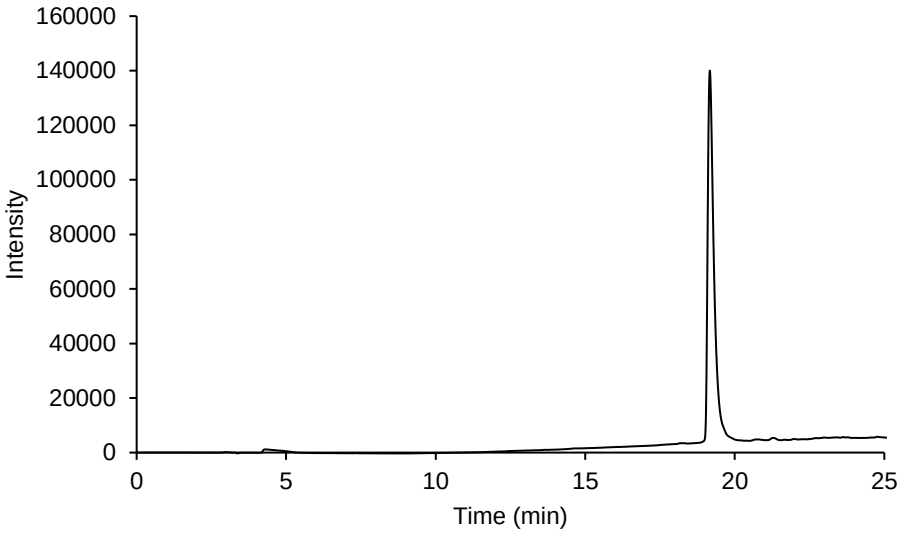


Figure S9. HPLC chromatogram of macropaquin. Retention time (t_R) = 19.166 min using a binary MeOH/H_2O mobile phase containing 0.1% TFA.

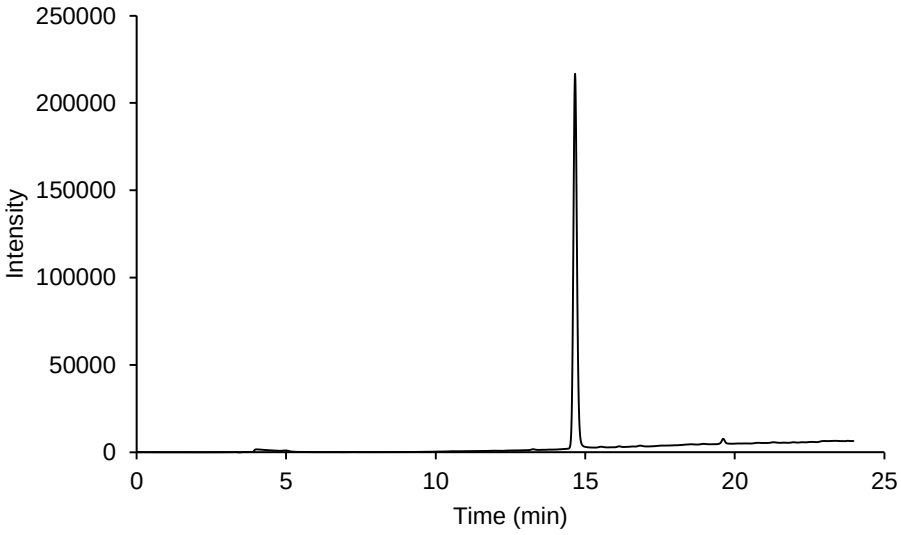


Figure S10. HPLC chromatogram of macroquin-SO_3. Retention time (t_R) = 14.660 min using a binary MeOH/H_2O mobile phase containing 0.1% TFA. The small peak with a $t_R \approx$ 19.4 min is a minor unidentified impurity.

2.1.3 High-Resolution Mass Spectra

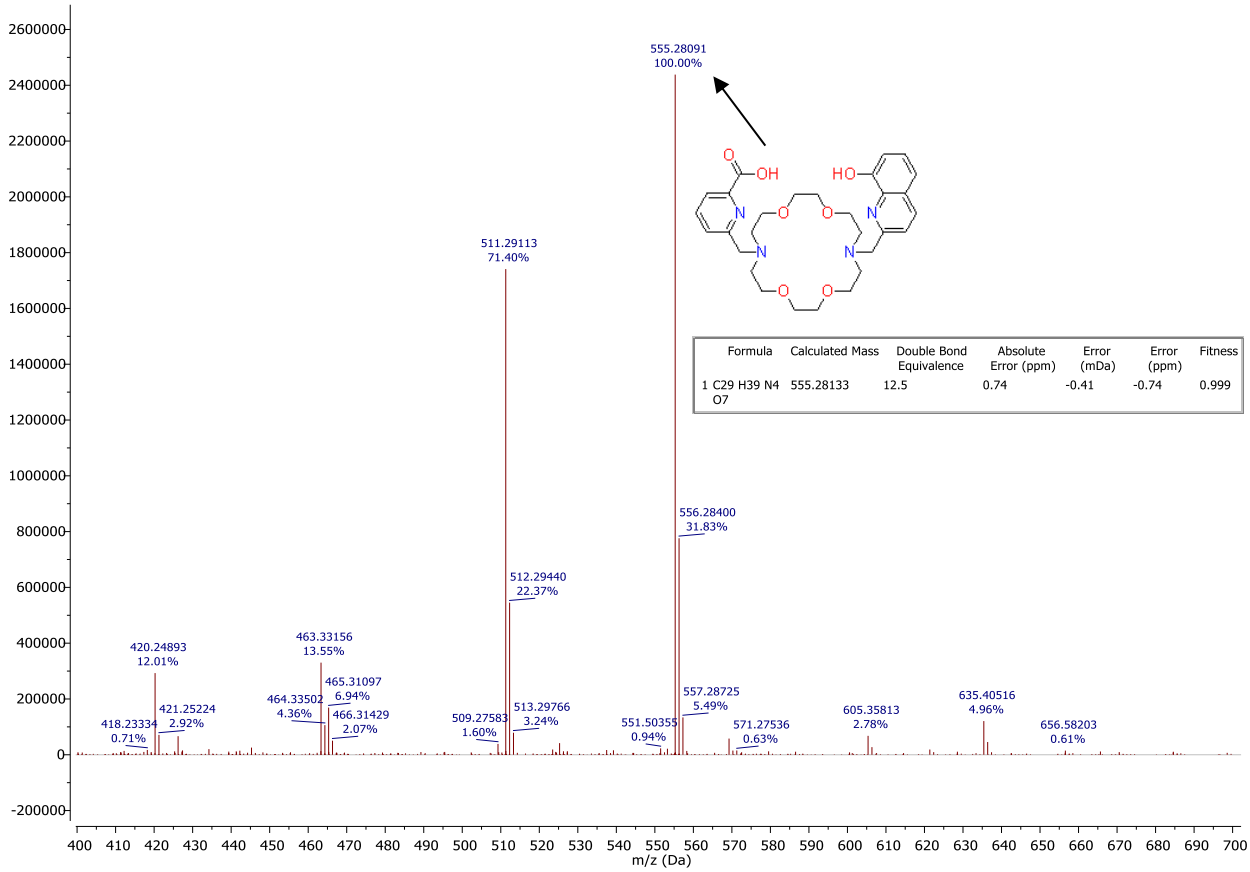


Figure S11. DART HRMS of macropaquin. An aliquot of ligand in H_2O was analyzed in DART mode using helium gas (300–500 °C). An *m/z* of 511.2913 corresponds to the loss of 1 COOH from the parent ion during analysis.

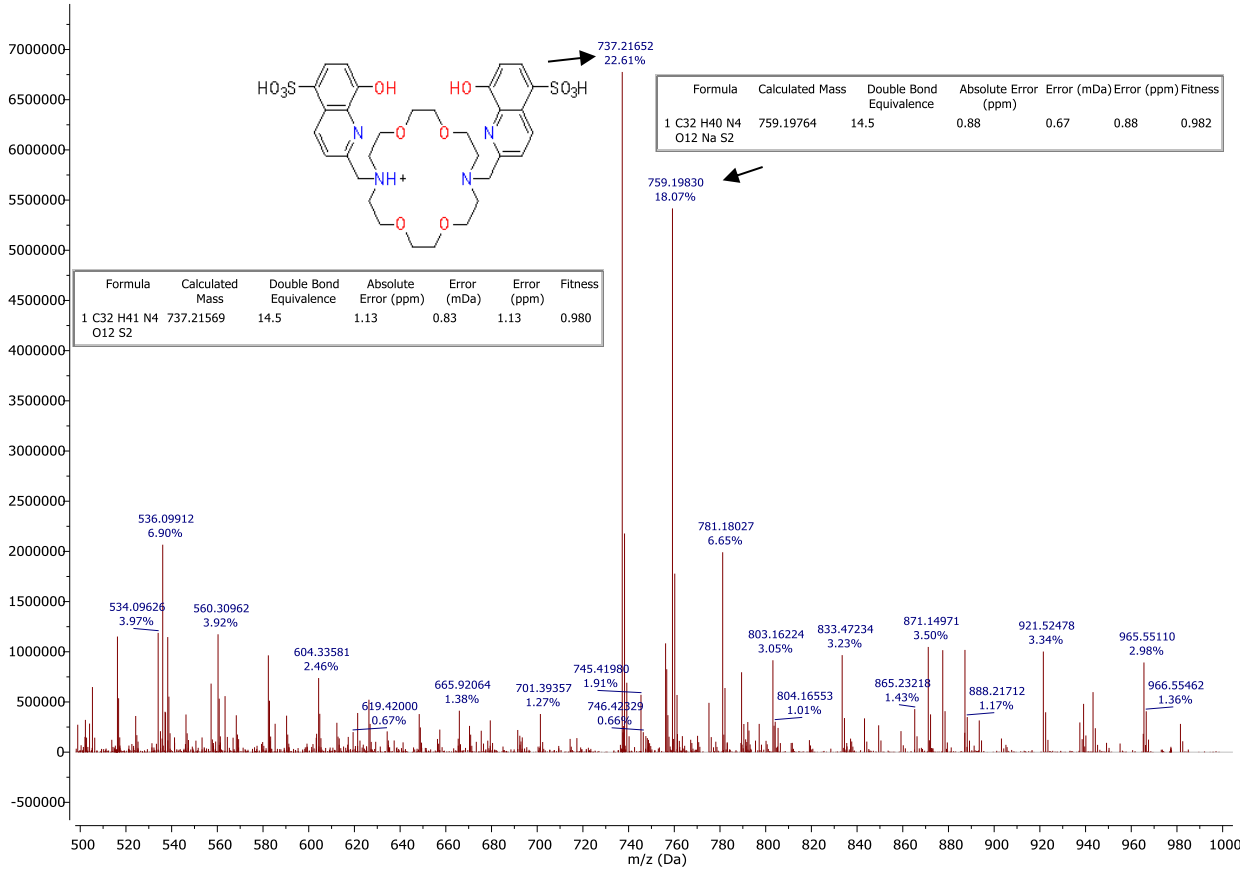


Figure S12. ESI HRMS of macroquin–SO_3. An aliquot of ligand in DMSO-d_6 was diluted with 7:3 CH_3CN:H_2O containing 0.1% formic acid before injection. A mobile phase of 7:3 CH_3CN:H_2O containing 0.1% formic acid was employed.

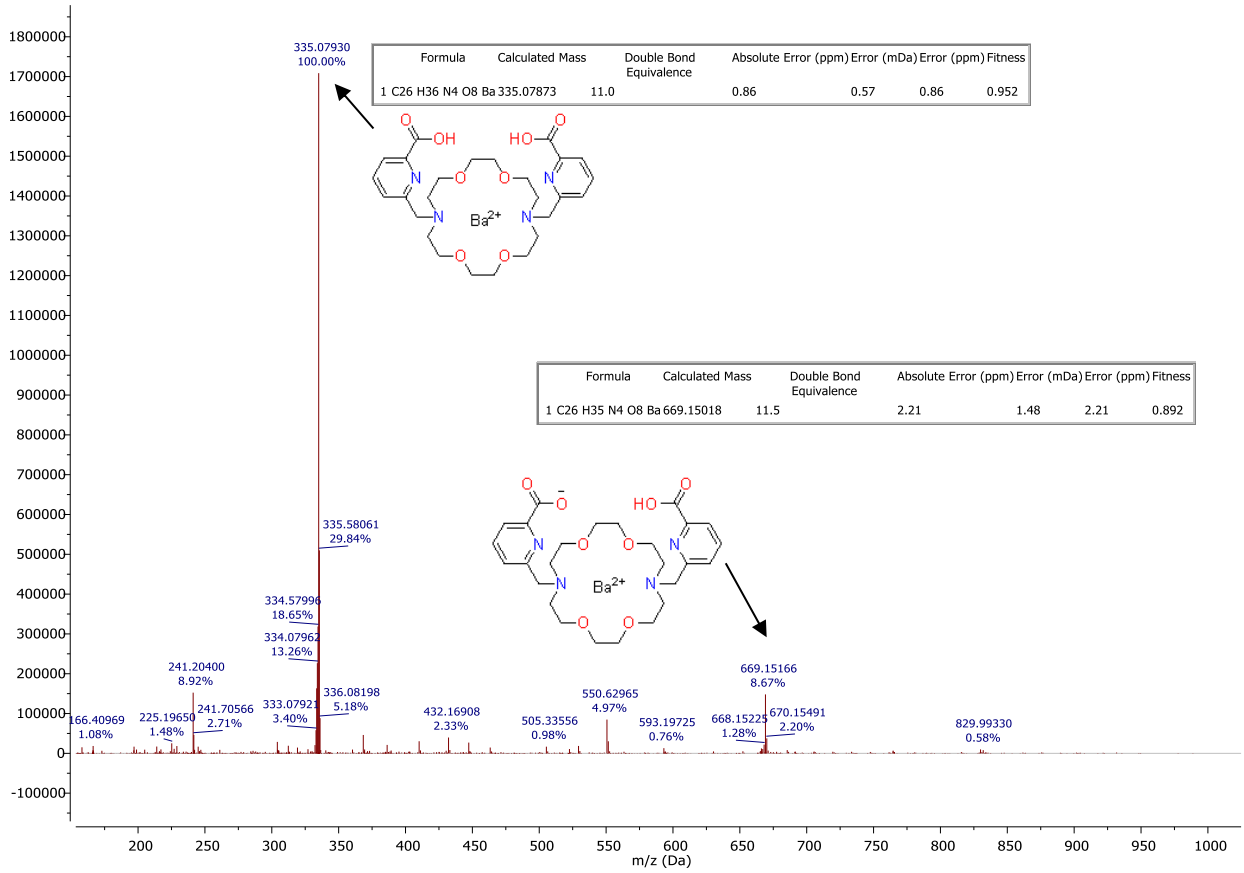


Figure S13. ESI HRMS of [Ba(Hmacropa)]$^{+}$. An aliquot of complex in dry DMF was diluted with CH_3CN before injection. A CH_3CN mobile phase without acid was employed. Two ions were detected, those of [Ba(Hmacropa)]$^{+}$ (*m/z* 669.15166) and [Ba(H_2macropa)]$^{2+}$ (*m/z* 335.07930).

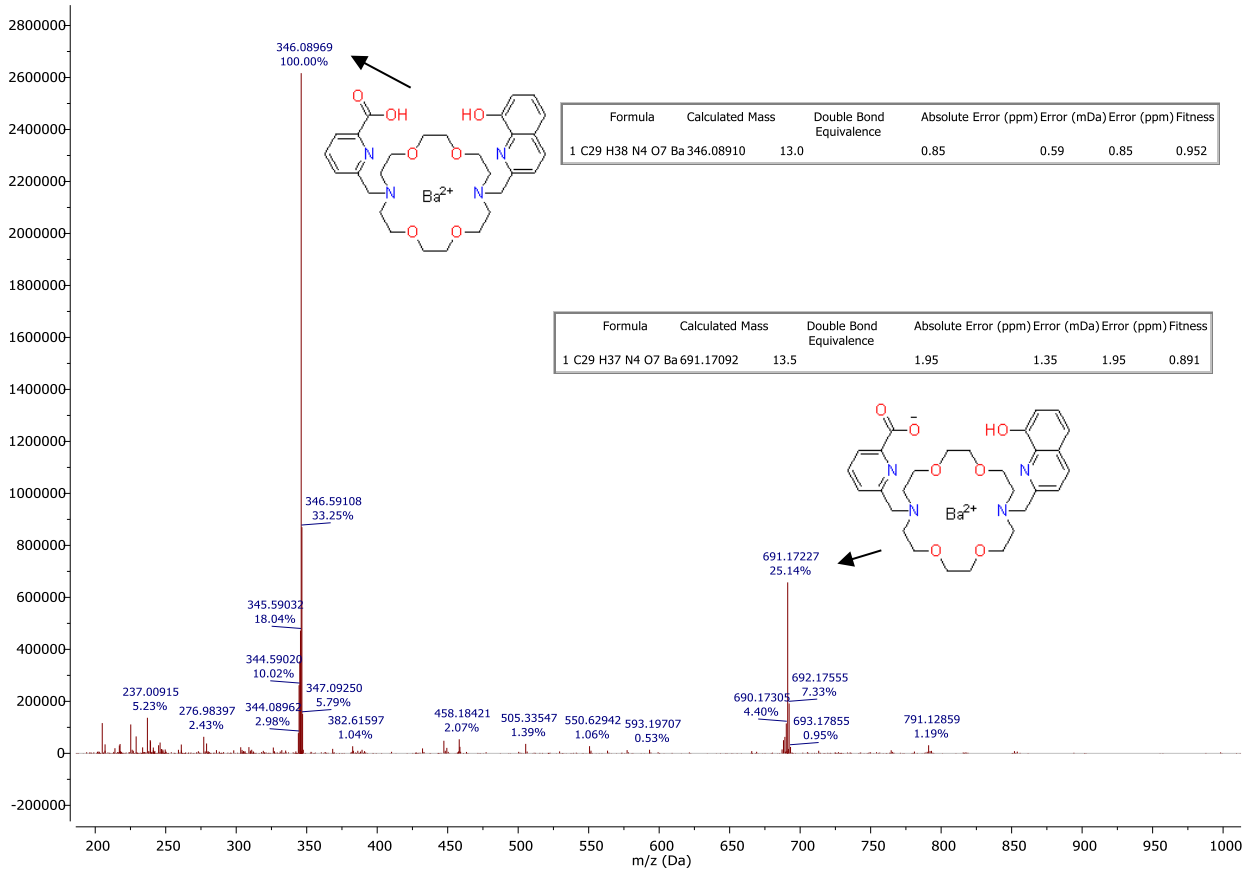


Figure S14. ESI HRMS of [Ba(Hmacropaquin)]$^{+}$. An aliquot of complex in dry DMF was diluted with CH_3CN before injection. A CH_3CN mobile phase without acid was employed. Two ions were detected, those of [Ba(Hmacropaquin)]$^{+}$ (*m/z* 661.17227) and [Ba(H_2macropaquin)]$^{2+}$ (*m/z* 346.08910).

2.2 Crystal Structures of Barium Complexes

Table S1. X-ray crystallographic data collection and refinement parameters for [Ba(Hmacropa)(DMF)]ClO_4•Et_2O, [Ba(Hmacropaquin)(DMF)]ClO_4•DMF, and [Ba(H_2macroquin-SO_3)(H_2O)]•$4H_2O$.

	[Ba(Hmacropa)(DMF)]$^+$	**[Ba(Hmacropaquin)(DMF)]$^+$**	**[Ba(H_2macroquin–SO_3)(H_2O)]**
formula	$C_{33}H_{52}BaClN_5O_{14}$	$C_{35}H_{51}BaClN_6O_{13}$	$C_{32}H_{56}BaN_4O_{21}S_2$
fw	915.58	936.60	1034.26
space group	$Pca2_1$	I 1 2/a 1	F d d 2
a, Å	14.3442(6)	18.37410(8)	28.83060(10)
b, Å	13.0303(5)	15.68602(6)	21.51320(10)
c, Å	21.5769(9)	28.35948(11)	13.92600(10)
α, deg	90	90	90
β, deg	90	92.4109(4)	90
γ, deg	90	90	90
V, Å^3	4032.9(3)	8166.44(5)	8637.44(8)
Z	4	8	8
ρ_{calcd}, mg·m^{-3}	1.508	1.524	1.591
T, K	223.15	100.00(10)	100.00
μ(Mo Kα), mm^{-1}	1.120	8.759	8.792
Θ range, deg	1.888 to 30.032	3.119 to 70.074	4.081 to 70.015
Completeness to Θ (%)	100.0	100.0	100.0
Total no. of data	78016	160245	40654
No. of unique data	11689	7767	3955
No. of parameters	496	605	302
R1[a] (%)	0.0347	0.0264	0.0142
wR2[b] (%)	0.0642	0.0700	0.0374
GOF[c]	1.060	1.036	1.133
max, min peaks, e·Å^{-3}	0.834, -0.733	0.564, -0.785	0.320, -0.239

[a] $R_1 = \Sigma||F_o| - |F_c||/\Sigma|F_o|$ for $I > 2\sigma$. [b] $wR_2 = \{\Sigma[w(F_o^2 - F_c^2)^2]/\Sigma[w(F_o^2)^2]\}^{1/2}$ for $I > 2\sigma$. [c] GoF = $\{\Sigma[w(F_o^2 - F_c^2)^2]/(n - p)\}^{1/2}$, where n is the number of data and p is the number of refined parameters.

Table S2. Bond lengths [Å] and angles [°] for [Ba(Hmacropa)(DMF)]ClO_4•Et_2O.

Ba-O(1)	2.834(3)
Ba-O(2)	2.883(3)
Ba-O(3)	2.846(3)
Ba-O(4)	2.882(3)
Ba-O(5)	2.809(3)
Ba-O(7)	2.784(3)
Ba-O(9)	2.925(3)
Ba-N(1)	3.006(4)
Ba-N(2)	3.014(4)
Ba-N(3)	2.930(5)
Ba-N(4)	2.932(5)
O(1)-C(2)	1.428(7)
O(1)-C(3)	1.432(6)
O(2)-C(4)	1.421(6)
O(2)-C(5)	1.425(5)
O(3)-C(8)	1.413(7)
O(3)-C(9)	1.430(6)
O(4)-C(10)	1.436(7)
O(4)-C(11)	1.435(5)
O(5)-C(19)	1.224(5)
O(6)-C(19)	1.282(5)
O(7)-C(26)	1.226(5)
O(8)-H(8)	0.85(3)
O(8)-C(26)	1.280(6)
O(9)-C(27)	1.217(7)
N(1)-C(1)	1.473(6)
N(1)-C(12)	1.480(7)
N(1)-C(13)	1.482(6)
N(2)-C(6)	1.474(6)
N(2)-C(7)	1.477(6)
N(2)-C(20)	1.478(6)
N(3)-C(14)	1.344(7)
N(3)-C(18)	1.343(6)
N(4)-C(21)	1.343(6)

N(4)-C(25)	1.323(6)
N(5)-C(27)	1.326(7)
N(5)-C(28)	1.444(8)
N(5)-C(29)	1.439(10)
C(1)-H(1A)	0.9800
C(1)-H(1B)	0.9800
C(1)-C(2)	1.518(9)
C(2)-H(2A)	0.9800
C(2)-H(2B)	0.9800
C(3)-H(3A)	0.9800
C(3)-H(3B)	0.9800
C(3)-C(4)	1.501(7)
C(4)-H(4A)	0.9800
C(4)-H(4B)	0.9800
C(5)-H(5A)	0.9800
C(5)-H(5B)	0.9800
C(5)-C(6)	1.515(7)
C(6)-H(6A)	0.9800
C(6)-H(6B)	0.9800
C(7)-H(7A)	0.9800
C(7)-H(7B)	0.9800
C(7)-C(8)	1.504(7)
C(8)-H(8A)	0.9800
C(8)-H(8B)	0.9800
C(9)-H(9A)	0.9800
C(9)-H(9B)	0.9800
C(9)-C(10)	1.488(8)
C(10)-H(10A)	0.9800
C(10)-H(10B)	0.9800
C(11)-H(11A)	0.9800
C(11)-H(11B)	0.9800
C(11)-C(12)	1.491(8)
C(12)-H(12A)	0.9800
C(12)-H(12B)	0.9800
C(13)-H(13A)	0.9800
C(13)-H(13B)	0.9800

C(13)-C(14)	1.503(7)
C(14)-C(15)	1.376(7)
C(15)-H(15)	0.9400
C(15)-C(16)	1.381(9)
C(16)-H(16)	0.9400
C(16)-C(17)	1.369(8)
C(17)-H(17)	0.9400
C(17)-C(18)	1.379(7)
C(18)-C(19)	1.511(7)
C(20)-H(20A)	0.9800
C(20)-H(20B)	0.9800
C(20)-C(21)	1.496(7)
C(21)-C(22)	1.386(7)
C(22)-H(22)	0.9400
C(22)-C(23)	1.367(9)
C(23)-H(23)	0.9400
C(23)-C(24)	1.373(9)
C(24)-H(24)	0.9400
C(24)-C(25)	1.399(7)
C(25)-C(26)	1.512(7)
C(27)-H(27)	0.9400
C(28)-H(28A)	0.9700
C(28)-H(28B)	0.9700
C(28)-H(28C)	0.9700
C(29)-H(29A)	0.9700
C(29)-H(29B)	0.9700
C(29)-H(29C)	0.9700
Cl(1)-O(10)	1.426(4)
Cl(1)-O(12)	1.382(5)
Cl(1)-O(11A)	1.456(9)
Cl(1)-O(13B)	1.393(18)
Cl(1)-O(11B)	1.396(15)
Cl(1)-O(13A)	1.495(10)
O(14)-C(31)	1.387(9)
O(14)-C(32)	1.356(10)
C(30)-H(30A)	0.9700

C(30)-H(30B)	0.9700
C(30)-H(30C)	0.9700
C(30)-C(31)	1.402(11)
C(31)-H(31A)	0.9800
C(31)-H(31B)	0.9800
C(32)-H(32A)	0.9800
C(32)-H(32B)	0.9800
C(32)-C(33)	1.480(10)
C(33)-H(33A)	0.9700
C(33)-H(33B)	0.9700
C(33)-H(33C)	0.9700

O(1)-Ba-O(2)	59.48(9)
O(1)-Ba-O(3)	141.30(9)
O(1)-Ba-O(4)	102.82(9)
O(1)-Ba-O(9)	71.35(16)
O(1)-Ba-N(1)	60.06(10)
O(1)-Ba-N(2)	119.82(10)
O(1)-Ba-N(3)	73.04(12)
O(1)-Ba-N(4)	143.29(12)
O(2)-Ba-O(9)	65.24(9)
O(2)-Ba-N(1)	119.26(10)
O(2)-Ba-N(2)	60.66(9)
O(2)-Ba-N(3)	109.36(10)
O(2)-Ba-N(4)	108.14(11)
O(3)-Ba-O(2)	103.31(9)
O(3)-Ba-O(4)	59.58(9)
O(3)-Ba-O(9)	69.95(16)
O(3)-Ba-N(1)	120.06(10)
O(3)-Ba-N(2)	60.28(9)
O(3)-Ba-N(3)	142.90(12)
O(3)-Ba-N(4)	72.68(11)
O(4)-Ba-O(2)	129.81(8)
O(4)-Ba-O(9)	64.57(9)
O(4)-Ba-N(1)	60.87(10)
O(4)-Ba-N(2)	119.49(10)

O(4)-Ba-N(3)	108.29(10)
O(4)-Ba-N(4)	109.63(11)
O(5)-Ba-O(1)	77.91(9)
O(5)-Ba-O(2)	64.62(9)
O(5)-Ba-O(3)	128.95(9)
O(5)-Ba-O(4)	163.96(9)
O(5)-Ba-O(9)	129.38(9)
O(5)-Ba-N(1)	107.52(10)
O(5)-Ba-N(2)	72.10(9)
O(5)-Ba-N(3)	56.26(10)
O(5)-Ba-N(4)	66.15(11)
O(7)-Ba-O(1)	128.83(9)
O(7)-Ba-O(2)	163.89(9)
O(7)-Ba-O(3)	77.80(10)
O(7)-Ba-O(4)	64.89(9)
O(7)-Ba-O(5)	101.91(9)
O(7)-Ba-O(9)	128.71(10)
O(7)-Ba-N(1)	72.02(10)
O(7)-Ba-N(2)	107.97(10)
O(7)-Ba-N(3)	65.94(12)
O(7)-Ba-N(4)	56.48(11)
O(9)-Ba-N(1)	90.80(15)
O(9)-Ba-N(2)	89.50(15)
O(9)-Ba-N(3)	140.53(19)
O(9)-Ba-N(4)	138.73(18)
N(1)-Ba-N(2)	179.61(10)
N(3)-Ba-N(1)	56.38(11)
N(3)-Ba-N(2)	123.25(11)
N(3)-Ba-N(4)	80.74(9)
N(4)-Ba-N(1)	123.37(12)
N(4)-Ba-N(2)	56.46(11)
C(2)-O(1)-Ba	114.8(3)
C(2)-O(1)-C(3)	111.9(4)
C(3)-O(1)-Ba	117.3(3)
C(4)-O(2)-Ba	110.9(3)
C(4)-O(2)-C(5)	111.9(4)

C(5)-O(2)-Ba	115.4(3)
C(8)-O(3)-Ba	112.8(3)
C(8)-O(3)-C(9)	112.6(4)
C(9)-O(3)-Ba	116.1(3)
C(10)-O(4)-Ba	112.3(3)
C(11)-O(4)-Ba	114.5(3)
C(11)-O(4)-C(10)	111.8(4)
C(19)-O(5)-Ba	123.0(3)
C(26)-O(7)-Ba	124.3(3)
C(26)-O(8)-H(8)	118(4)
C(27)-O(9)-Ba	152.0(6)
C(1)-N(1)-Ba	110.7(3)
C(1)-N(1)-C(12)	110.2(4)
C(1)-N(1)-C(13)	108.8(4)
C(12)-N(1)-Ba	108.3(3)
C(12)-N(1)-C(13)	109.2(4)
C(13)-N(1)-Ba	109.7(3)
C(6)-N(2)-Ba	108.9(3)
C(6)-N(2)-C(7)	109.0(4)
C(6)-N(2)-C(20)	110.1(4)
C(7)-N(2)-Ba	110.4(3)
C(7)-N(2)-C(20)	109.4(3)
C(20)-N(2)-Ba	109.2(2)
C(14)-N(3)-Ba	122.1(3)
C(18)-N(3)-Ba	119.5(3)
C(18)-N(3)-C(14)	118.1(5)
C(21)-N(4)-Ba	121.7(3)
C(25)-N(4)-Ba	119.2(3)
C(25)-N(4)-C(21)	119.1(4)
C(27)-N(5)-C(28)	120.9(6)
C(27)-N(5)-C(29)	120.8(5)
C(29)-N(5)-C(28)	118.2(5)
N(1)-C(1)-H(1A)	108.8
N(1)-C(1)-H(1B)	108.8
N(1)-C(1)-C(2)	114.0(4)
H(1A)-C(1)-H(1B)	107.7

C(2)-C(1)-H(1A)	108.8
C(2)-C(1)-H(1B)	108.8
O(1)-C(2)-C(1)	107.5(5)
O(1)-C(2)-H(2A)	110.2
O(1)-C(2)-H(2B)	110.2
C(1)-C(2)-H(2A)	110.2
C(1)-C(2)-H(2B)	110.2
H(2A)-C(2)-H(2B)	108.5
O(1)-C(3)-H(3A)	110.1
O(1)-C(3)-H(3B)	110.1
O(1)-C(3)-C(4)	108.0(4)
H(3A)-C(3)-H(3B)	108.4
C(4)-C(3)-H(3A)	110.1
C(4)-C(3)-H(3B)	110.1
O(2)-C(4)-C(3)	109.2(4)
O(2)-C(4)-H(4A)	109.8
O(2)-C(4)-H(4B)	109.8
C(3)-C(4)-H(4A)	109.8
C(3)-C(4)-H(4B)	109.8
H(4A)-C(4)-H(4B)	108.3
O(2)-C(5)-H(5A)	109.9
O(2)-C(5)-H(5B)	109.9
O(2)-C(5)-C(6)	109.1(4)
H(5A)-C(5)-H(5B)	108.3
C(6)-C(5)-H(5A)	109.9
C(6)-C(5)-H(5B)	109.9
N(2)-C(6)-C(5)	114.1(4)
N(2)-C(6)-H(6A)	108.7
N(2)-C(6)-H(6B)	108.7
C(5)-C(6)-H(6A)	108.7
C(5)-C(6)-H(6B)	108.7
H(6A)-C(6)-H(6B)	107.6
N(2)-C(7)-H(7A)	108.9
N(2)-C(7)-H(7B)	108.9
N(2)-C(7)-C(8)	113.5(4)
H(7A)-C(7)-H(7B)	107.7

C(8)-C(7)-H(7A)	108.9
C(8)-C(7)-H(7B)	108.9
O(3)-C(8)-C(7)	109.5(5)
O(3)-C(8)-H(8A)	109.8
O(3)-C(8)-H(8B)	109.8
C(7)-C(8)-H(8A)	109.8
C(7)-C(8)-H(8B)	109.8
H(8A)-C(8)-H(8B)	108.2
O(3)-C(9)-H(9A)	109.7
O(3)-C(9)-H(9B)	109.7
O(3)-C(9)-C(10)	109.9(4)
H(9A)-C(9)-H(9B)	108.2
C(10)-C(9)-H(9A)	109.7
C(10)-C(9)-H(9B)	109.7
O(4)-C(10)-C(9)	108.6(4)
O(4)-C(10)-H(10A)	110.0
O(4)-C(10)-H(10B)	110.0
C(9)-C(10)-H(10A)	110.0
C(9)-C(10)-H(10B)	110.0
H(10A)-C(10)-H(10B)	108.4
O(4)-C(11)-H(11A)	110.0
O(4)-C(11)-H(11B)	110.0
O(4)-C(11)-C(12)	108.6(4)
H(11A)-C(11)-H(11B)	108.3
C(12)-C(11)-H(11A)	110.0
C(12)-C(11)-H(11B)	110.0
N(1)-C(12)-C(11)	114.8(4)
N(1)-C(12)-H(12A)	108.6
N(1)-C(12)-H(12B)	108.6
C(11)-C(12)-H(12A)	108.6
C(11)-C(12)-H(12B)	108.6
H(12A)-C(12)-H(12B)	107.5
N(1)-C(13)-H(13A)	109.0
N(1)-C(13)-H(13B)	109.0
N(1)-C(13)-C(14)	112.8(4)
H(13A)-C(13)-H(13B)	107.8

C(14)-C(13)-H(13A)	109.0
C(14)-C(13)-H(13B)	109.0
N(3)-C(14)-C(13)	117.3(4)
N(3)-C(14)-C(15)	121.3(5)
C(15)-C(14)-C(13)	121.3(4)
C(14)-C(15)-H(15)	119.8
C(14)-C(15)-C(16)	120.4(5)
C(16)-C(15)-H(15)	119.8
C(15)-C(16)-H(16)	120.9
C(17)-C(16)-C(15)	118.2(6)
C(17)-C(16)-H(16)	120.9
C(16)-C(17)-H(17)	120.4
C(16)-C(17)-C(18)	119.1(5)
C(18)-C(17)-H(17)	120.4
N(3)-C(18)-C(17)	122.8(5)
N(3)-C(18)-C(19)	114.8(4)
C(17)-C(18)-C(19)	122.3(4)
O(5)-C(19)-O(6)	125.3(5)
O(5)-C(19)-C(18)	120.0(4)
O(6)-C(19)-C(18)	114.7(4)
N(2)-C(20)-H(20A)	109.1
N(2)-C(20)-H(20B)	109.1
N(2)-C(20)-C(21)	112.6(4)
H(20A)-C(20)-H(20B)	107.8
C(21)-C(20)-H(20A)	109.1
C(21)-C(20)-H(20B)	109.1
N(4)-C(21)-C(20)	117.7(4)
N(4)-C(21)-C(22)	120.8(5)
C(22)-C(21)-C(20)	121.4(4)
C(21)-C(22)-H(22)	120.1
C(23)-C(22)-C(21)	119.7(5)
C(23)-C(22)-H(22)	120.1
C(22)-C(23)-H(23)	120.0
C(22)-C(23)-C(24)	120.0(5)
C(24)-C(23)-H(23)	120.0
C(23)-C(24)-H(24)	121.4

C(23)-C(24)-C(25)	117.2(5)
C(25)-C(24)-H(24)	121.4
N(4)-C(25)-C(24)	123.2(5)
N(4)-C(25)-C(26)	115.9(4)
C(24)-C(25)-C(26)	120.9(4)
O(7)-C(26)-O(8)	125.3(4)
O(7)-C(26)-C(25)	119.2(4)
O(8)-C(26)-C(25)	115.5(4)
O(9)-C(27)-N(5)	125.6(6)
O(9)-C(27)-H(27)	117.2
N(5)-C(27)-H(27)	117.2
N(5)-C(28)-H(28A)	109.5
N(5)-C(28)-H(28B)	109.5
N(5)-C(28)-H(28C)	109.5
H(28A)-C(28)-H(28B)	109.5
H(28A)-C(28)-H(28C)	109.5
H(28B)-C(28)-H(28C)	109.5
N(5)-C(29)-H(29A)	109.5
N(5)-C(29)-H(29B)	109.5
N(5)-C(29)-H(29C)	109.5
H(29A)-C(29)-H(29B)	109.5
H(29A)-C(29)-H(29C)	109.5
H(29B)-C(29)-H(29C)	109.5
O(10)-Cl(1)-O(11A)	106.7(4)
O(10)-Cl(1)-O(13A)	106.6(4)
O(12)-Cl(1)-O(10)	111.3(3)
O(12)-Cl(1)-O(11A)	97.8(5)
O(12)-Cl(1)-O(13B)	120.5(7)
O(12)-Cl(1)-O(11B)	129.3(7)
O(12)-Cl(1)-O(13A)	99.2(5)
O(13B)-Cl(1)-O(10)	116.2(6)
O(13B)-Cl(1)-O(11A)	100.6(8)
O(11B)-Cl(1)-O(10)	110.1(7)
O(11B)-Cl(1)-O(13A)	95.8(8)
C(32)-O(14)-C(31)	117.7(7)
H(30A)-C(30)-H(30B)	109.5

H(30A)-C(30)-H(30C)	109.5
H(30B)-C(30)-H(30C)	109.5
C(31)-C(30)-H(30A)	109.5
C(31)-C(30)-H(30B)	109.5
C(31)-C(30)-H(30C)	109.5
O(14)-C(31)-C(30)	114.9(7)
O(14)-C(31)-H(31A)	108.5
O(14)-C(31)-H(31B)	108.5
C(30)-C(31)-H(31A)	108.5
C(30)-C(31)-H(31B)	108.5
H(31A)-C(31)-H(31B)	107.5
O(14)-C(32)-H(32A)	109.3
O(14)-C(32)-H(32B)	109.3
O(14)-C(32)-C(33)	111.8(8)
H(32A)-C(32)-H(32B)	107.9
C(33)-C(32)-H(32A)	109.3
C(33)-C(32)-H(32B)	109.3
C(32)-C(33)-H(33A)	109.5
C(32)-C(33)-H(33B)	109.5
C(32)-C(33)-H(33C)	109.5
H(33A)-C(33)-H(33B)	109.5
H(33A)-C(33)-H(33C)	109.5
H(33B)-C(33)-H(33C)	109.5

Table S3. Bond lengths [Å] and angles [°] for [Ba(Hmacropaquin)(DMF)]ClO_4•DMF.

C34-H3C4	0.9800
C23-H2C3	0.9800
N14-C34	1.496(14)
Cl11-O41	1.366(7)
C14-O14	1.211(12)
Cl11-O31	1.408(7)
C34-H3A4	0.9800
Cl11-O21	1.409(8)
C33-H3B3	0.9800
Cl11-O11	1.431(9)
C14-H14	0.9500
C34-H3B4	0.9800
C24-H2B4	0.9800
Cl12-O22	1.397(6)
C23-H2B3	0.9800
Cl12-O12	1.434(6)
C33-H3A3	0.9800
Cl12-O42	1.449(7)
C33-H3C3	0.9800
C13-O13	1.228(10)
C14-N14	1.309(12)
C13-N13	1.321(10)
N14-C24	1.437(12)
C13-H13	0.9500
C24-H2A4	0.9800
N13-C23	1.443(7)
C24-H2C4	0.9800
N13-C33	1.454(8)
C23-H2A3	0.9800
Cl12-O32	1.396(6)
Ba-O(1)	2.8168(17)
Ba-O(2)	2.8771(17)
Ba-O(3)	2.8391(16)
Ba-O(4)	2.8719(16)

Ba-O(5)	2.8098(16)
Ba-O(7)	2.9680(15)
Ba-O(8)	2.838(2)
Ba-N(1)	3.007(2)
Ba-N(2)	2.960(2)
Ba-N(3)	2.865(2)
Ba-N(4)	2.9353(18)
O(1)-C(2)	1.435(3)
O(1)-C(3)	1.421(3)
O(2)-C(4)	1.425(3)
O(2)-C(5)	1.424(3)
O(3)-C(8)	1.429(3)
O(3)-C(9)	1.429(3)
O(4)-C(10)	1.427(3)
O(4)-C(11)	1.437(3)
O(5)-C(19)	1.245(3)
O(6)-C(19)	1.264(3)
O(7)-H(7)	0.833(17)
O(7)-C(28)	1.357(3)
O(8)-C(30)	1.212(4)
N(1)-C(1)	1.481(3)
N(1)-C(12)	1.478(3)
N(1)-C(13)	1.463(4)
N(2)-C(6)	1.475(3)
N(2)-C(7)	1.482(3)
N(2)-C(20)	1.469(3)
N(3)-C(14)	1.341(3)
N(3)-C(18)	1.349(3)
N(4)-C(21)	1.322(3)
N(4)-C(29)	1.363(3)
N(5)-C(30)	1.341(4)
N(5)-C(31)	1.447(5)
N(5)-C(32)	1.451(4)
C(1)-H(1A)	0.9900
C(1)-H(1B)	0.9900
C(1)-C(2)	1.500(4)

C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-H(3A)	0.9900
C(3)-H(3B)	0.9900
C(3)-C(4)	1.492(4)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-H(5A)	0.9900
C(5)-H(5B)	0.9900
C(5)-C(6)	1.511(4)
C(6)-H(6A)	0.9900
C(6)-H(6B)	0.9900
C(7)-H(7A)	0.9900
C(7)-H(7B)	0.9900
C(7)-C(8)	1.510(4)
C(8)-H(8A)	0.9900
C(8)-H(8B)	0.9900
C(9)-H(9A)	0.9900
C(9)-H(9B)	0.9900
C(9)-C(10)	1.496(4)
C(10)-H(10A)	0.9900
C(10)-H(10B)	0.9900
C(11)-H(11A)	0.9900
C(11)-H(11B)	0.9900
C(11)-C(12)	1.507(4)
C(12)-H(12A)	0.9900
C(12)-H(12B)	0.9900
C(13)-H(13A)	0.9900
C(13)-H(13B)	0.9900
C(13)-C(14)	1.512(4)
C(14)-C(15)	1.387(4)
C(15)-H(15)	0.9500
C(15)-C(16)	1.375(4)
C(16)-H(16)	0.9500
C(16)-C(17)	1.393(4)
C(17)-H(17)	0.9500

C(17)-C(18)	1.381(3)
C(18)-C(19)	1.528(3)
C(20)-H(20A)	0.9900
C(20)-H(20B)	0.9900
C(20)-C(21)	1.504(3)
C(21)-C(22)	1.414(3)
C(22)-H(22)	0.9500
C(22)-C(23)	1.354(4)
C(23)-H(23)	0.9500
C(23)-C(24)	1.414(4)
C(24)-C(25)	1.414(4)
C(24)-C(29)	1.423(3)
C(25)-H(25)	0.9500
C(25)-C(26)	1.360(4)
C(26)-H(26)	0.9500
C(26)-C(27)	1.410(4)
C(27)-H(27)	0.9500
C(27)-C(28)	1.376(3)
C(28)-C(29)	1.423(3)
C(30)-H(30)	0.9500
C(31)-H(31A)	0.9800
C(31)-H(31B)	0.9800
C(31)-H(31C)	0.9800
C(32)-H(32A)	0.9800
C(32)-H(32B)	0.9800
C(32)-H(32C)	0.9800

O(1)-Ba-O(2)	59.07(5)
O(1)-Ba-O(3)	140.80(5)
H3A4-C34-H3B4	109.5
O32-Cl12-O12	100.3(5)
C14-N14-C24	122.5(11)
O14-C14-N14	122.5(12)
O(1)-Ba-O(4)	101.24(5)
N14-C14-H14	118.8
O22-Cl12-O42	113.8(4)

O12-Cl12-O42	101.0(5)
N13-C13-H13	118.4
N14-C24-H2B4	109.5
C13-N13-C33	118.8(6)
H2A3-C23-H2B3	109.5
C23-N13-C33	118.0(6)
N14-C34-H3C4	109.5
O13-C13-N13	123.3(9)
H2B3-C23-H2C3	109.5
O32-Cl12-O42	114.9(4)
N14-C34-H3B4	109.5
H3A3-C33-H3C3	109.5
H3B3-C33-H3C3	109.5
O41-Cl11-O31	111.4(7)
O(1)-Ba-O(7)	133.48(5)
O(1)-Ba-O(8)	73.82(6)
O(1)-Ba-N(1)	60.97(5)
O(1)-Ba-N(2)	119.07(5)
O(1)-Ba-N(3)	75.52(6)
O22-Cl12-O12	107.1(5)
C24-N14-C34	118.1(11)
N13-C33-H3B3	109.5
N13-C33-H3A3	109.5
O21-Cl11-O11	110.6(5)
H2A3-C23-H2C3	109.5
C13-N13-C23	123.1(6)
O(1)-Ba-N(4)	139.87(5)
O31-Cl11-O11	107.7(8)
N14-C24-H2C4	109.5
H3B4-C34-H3C4	109.5
O31-Cl11-O21	110.6(7)
N13-C23-H2A3	109.5
H3A4-C34-H3C4	109.5
O32-Cl12-O22	117.0(5)
H3A3-C33-H3B3	109.5
N13-C23-H2B3	109.5

N13-C23-H2C3	109.5
C14-N14-C34	119.3(9)
O13-C13-H13	118.4
H2A4-C24-H2B4	109.5
O14-C14-H14	118.8
O(2)-Ba-O(7)	161.89(5)
O(2)-Ba-N(1)	119.43(5)
O(2)-Ba-N(2)	60.58(5)
O(2)-Ba-N(4)	107.57(5)
O(3)-Ba-O(2)	103.21(5)
O(3)-Ba-O(4)	59.41(5)
N14-C34-H3A4	109.5
O41-Cl11-O21	110.1(7)
O(3)-Ba-O(7)	74.23(5)
O(3)-Ba-N(1)	117.74(5)
O(3)-Ba-N(2)	62.16(5)
O(3)-Ba-N(3)	139.66(5)
O(3)-Ba-N(4)	76.59(5)
O(4)-Ba-O(2)	126.91(5)
O(4)-Ba-O(7)	67.83(4)
O41-Cl11-O11	106.4(7)
H2B4-C24-H2C4	109.5
H2A4-C24-H2C4	109.5
N13-C33-H3C3	109.5
N14-C24-H2A4	109.5
O(4)-Ba-N(1)	58.91(5)
O(4)-Ba-N(2)	120.98(5)
O(4)-Ba-N(4)	114.47(5)
O(5)-Ba-O(1)	75.31(5)
O(5)-Ba-O(2)	66.06(5)
O(5)-Ba-O(3)	132.89(5)
O(5)-Ba-O(4)	162.98(5)
O(5)-Ba-O(7)	102.10(4)
O(5)-Ba-O(8)	128.72(5)
O(5)-Ba-N(1)	106.16(5)
O(5)-Ba-N(2)	73.95(5)

O(5)-Ba-N(3)	57.26(5)
O(5)-Ba-N(4)	65.14(5)
O(7)-Ba-N(1)	76.18(5)
O(8)-Ba-O(2)	63.07(6)
O(8)-Ba-O(3)	67.07(6)
O(8)-Ba-O(4)	64.10(6)
O(8)-Ba-O(7)	128.80(5)
O(8)-Ba-N(1)	93.18(7)
O(8)-Ba-N(2)	86.72(7)
O(8)-Ba-N(3)	144.61(7)
O(8)-Ba-N(4)	137.78(7)
N(2)-Ba-O(7)	103.83(5)
N(2)-Ba-N(1)	179.88(6)
N(3)-Ba-O(2)	113.89(5)
N(3)-Ba-O(4)	105.73(5)
N(3)-Ba-O(7)	65.56(5)
N(3)-Ba-N(1)	56.11(6)
N(3)-Ba-N(2)	124.00(6)
N(3)-Ba-N(4)	77.61(5)
N(4)-Ba-O(7)	54.32(5)
N(4)-Ba-N(1)	123.32(6)
N(4)-Ba-N(2)	56.74(5)
C(2)-O(1)-Ba	116.40(14)
C(3)-O(1)-Ba	118.72(15)
C(3)-O(1)-C(2)	112.3(2)
C(4)-O(2)-Ba	112.92(15)
C(5)-O(2)-Ba	116.97(14)
C(5)-O(2)-C(4)	112.2(2)
C(8)-O(3)-Ba	112.98(14)
C(9)-O(3)-Ba	115.38(14)
C(9)-O(3)-C(8)	111.68(19)
C(10)-O(4)-Ba	115.38(14)
C(10)-O(4)-C(11)	112.81(19)
C(11)-O(4)-Ba	121.25(14)
C(19)-O(5)-Ba	122.42(14)
Ba-O(7)-H(7)	132.0(19)

C(28)-O(7)-Ba	118.05(13)
C(28)-O(7)-H(7)	108.1(19)
C(30)-O(8)-Ba	147.8(2)
C(1)-N(1)-Ba	108.28(15)
C(12)-N(1)-Ba	110.99(16)
C(12)-N(1)-C(1)	109.4(2)
C(13)-N(1)-Ba	108.90(13)
C(13)-N(1)-C(1)	109.6(2)
C(13)-N(1)-C(12)	109.7(2)
C(6)-N(2)-Ba	109.78(15)
C(6)-N(2)-C(7)	110.4(2)
C(7)-N(2)-Ba	108.28(14)
C(20)-N(2)-Ba	109.55(13)
C(20)-N(2)-C(6)	109.8(2)
C(20)-N(2)-C(7)	109.0(2)
C(14)-N(3)-Ba	119.23(15)
C(14)-N(3)-C(18)	118.3(2)
C(18)-N(3)-Ba	116.06(14)
C(21)-N(4)-Ba	118.15(14)
C(21)-N(4)-C(29)	118.36(19)
C(29)-N(4)-Ba	118.62(14)
C(30)-N(5)-C(31)	121.0(3)
C(30)-N(5)-C(32)	121.5(3)
C(31)-N(5)-C(32)	117.5(3)
N(1)-C(1)-H(1A)	108.7
N(1)-C(1)-H(1B)	108.7
N(1)-C(1)-C(2)	114.2(2)
H(1A)-C(1)-H(1B)	107.6
C(2)-C(1)-H(1A)	108.7
C(2)-C(1)-H(1B)	108.7
O(1)-C(2)-C(1)	108.6(2)
O(1)-C(2)-H(2A)	110.0
O(1)-C(2)-H(2B)	110.0
C(1)-C(2)-H(2A)	110.0
C(1)-C(2)-H(2B)	110.0
H(2A)-C(2)-H(2B)	108.4

O(1)-C(3)-H(3A)	109.8
O(1)-C(3)-H(3B)	109.8
O(1)-C(3)-C(4)	109.3(2)
H(3A)-C(3)-H(3B)	108.3
C(4)-C(3)-H(3A)	109.8
C(4)-C(3)-H(3B)	109.8
O(2)-C(4)-C(3)	109.5(2)
O(2)-C(4)-H(4A)	109.8
O(2)-C(4)-H(4B)	109.8
C(3)-C(4)-H(4A)	109.8
C(3)-C(4)-H(4B)	109.8
H(4A)-C(4)-H(4B)	108.2
O(2)-C(5)-H(5A)	109.9
O(2)-C(5)-H(5B)	109.9
O(2)-C(5)-C(6)	109.0(2)
H(5A)-C(5)-H(5B)	108.3
C(6)-C(5)-H(5A)	109.9
C(6)-C(5)-H(5B)	109.9
N(2)-C(6)-C(5)	113.6(2)
N(2)-C(6)-H(6A)	108.8
N(2)-C(6)-H(6B)	108.8
C(5)-C(6)-H(6A)	108.8
C(5)-C(6)-H(6B)	108.8
H(6A)-C(6)-H(6B)	107.7
N(2)-C(7)-H(7A)	108.8
N(2)-C(7)-H(7B)	108.8
N(2)-C(7)-C(8)	113.9(2)
H(7A)-C(7)-H(7B)	107.7
C(8)-C(7)-H(7A)	108.8
C(8)-C(7)-H(7B)	108.8
O(3)-C(8)-C(7)	109.1(2)
O(3)-C(8)-H(8A)	109.9
O(3)-C(8)-H(8B)	109.9
C(7)-C(8)-H(8A)	109.9
C(7)-C(8)-H(8B)	109.9
H(8A)-C(8)-H(8B)	108.3

O(3)-C(9)-H(9A)	109.7
O(3)-C(9)-H(9B)	109.7
O(3)-C(9)-C(10)	109.7(2)
H(9A)-C(9)-H(9B)	108.2
C(10)-C(9)-H(9A)	109.7
C(10)-C(9)-H(9B)	109.7
O(4)-C(10)-C(9)	109.2(2)
O(4)-C(10)-H(10A)	109.8
O(4)-C(10)-H(10B)	109.8
C(9)-C(10)-H(10A)	109.8
C(9)-C(10)-H(10B)	109.8
H(10A)-C(10)-H(10B)	108.3
O(4)-C(11)-H(11A)	110.0
O(4)-C(11)-H(11B)	110.0
O(4)-C(11)-C(12)	108.4(2)
H(11A)-C(11)-H(11B)	108.4
C(12)-C(11)-H(11A)	110.0
C(12)-C(11)-H(11B)	110.0
N(1)-C(12)-C(11)	113.7(2)
N(1)-C(12)-H(12A)	108.8
N(1)-C(12)-H(12B)	108.8
C(11)-C(12)-H(12A)	108.8
C(11)-C(12)-H(12B)	108.8
H(12A)-C(12)-H(12B)	107.7
N(1)-C(13)-H(13A)	108.7
N(1)-C(13)-H(13B)	108.7
N(1)-C(13)-C(14)	114.4(2)
H(13A)-C(13)-H(13B)	107.6
C(14)-C(13)-H(13A)	108.7
C(14)-C(13)-H(13B)	108.7
N(3)-C(14)-C(13)	117.9(2)
N(3)-C(14)-C(15)	122.1(2)
C(15)-C(14)-C(13)	120.0(2)
C(14)-C(15)-H(15)	120.1
C(16)-C(15)-C(14)	119.8(2)
C(16)-C(15)-H(15)	120.1

C(15)-C(16)-H(16)	120.8
C(15)-C(16)-C(17)	118.4(2)
C(17)-C(16)-H(16)	120.8
C(16)-C(17)-H(17)	120.5
C(18)-C(17)-C(16)	118.9(2)
C(18)-C(17)-H(17)	120.5
N(3)-C(18)-C(17)	122.5(2)
N(3)-C(18)-C(19)	115.85(19)
C(17)-C(18)-C(19)	121.7(2)
O(5)-C(19)-O(6)	127.0(2)
O(5)-C(19)-C(18)	118.40(19)
O(6)-C(19)-C(18)	114.6(2)
N(2)-C(20)-H(20A)	108.5
N(2)-C(20)-H(20B)	108.5
N(2)-C(20)-C(21)	115.1(2)
H(20A)-C(20)-H(20B)	107.5
C(21)-C(20)-H(20A)	108.5
C(21)-C(20)-H(20B)	108.5
N(4)-C(21)-C(20)	118.8(2)
N(4)-C(21)-C(22)	122.6(2)
C(22)-C(21)-C(20)	118.5(2)
C(21)-C(22)-H(22)	120.2
C(23)-C(22)-C(21)	119.5(2)
C(23)-C(22)-H(22)	120.2
C(22)-C(23)-H(23)	120.0
C(22)-C(23)-C(24)	120.1(2)
C(24)-C(23)-H(23)	120.0
C(23)-C(24)-C(29)	116.5(2)
C(25)-C(24)-C(23)	123.6(2)
C(25)-C(24)-C(29)	119.9(2)
C(24)-C(25)-H(25)	120.2
C(26)-C(25)-C(24)	119.7(2)
C(26)-C(25)-H(25)	120.2
C(25)-C(26)-H(26)	119.2
C(25)-C(26)-C(27)	121.6(2)
C(27)-C(26)-H(26)	119.2

C(26)-C(27)-H(27)	120.0
C(28)-C(27)-C(26)	120.0(2)
C(28)-C(27)-H(27)	120.0
O(7)-C(28)-C(27)	122.7(2)
O(7)-C(28)-C(29)	117.0(2)
C(27)-C(28)-C(29)	120.2(2)
N(4)-C(29)-C(24)	122.7(2)
N(4)-C(29)-C(28)	118.7(2)
C(24)-C(29)-C(28)	118.6(2)
O(8)-C(30)-N(5)	125.1(3)
O(8)-C(30)-H(30)	117.4
N(5)-C(30)-H(30)	117.4
N(5)-C(31)-H(31A)	109.5
N(5)-C(31)-H(31B)	109.5
N(5)-C(31)-H(31C)	109.5
H(31A)-C(31)-H(31B)	109.5
H(31A)-C(31)-H(31C)	109.5
H(31B)-C(31)-H(31C)	109.5
N(5)-C(32)-H(32A)	109.5
N(5)-C(32)-H(32B)	109.5
N(5)-C(32)-H(32C)	109.5
H(32A)-C(32)-H(32B)	109.5
H(32A)-C(32)-H(32C)	109.5
H(32B)-C(32)-H(32C)	109.5

Table S4. Bond lengths [Å] and angles [°] for [Ba(H_2macroquin-SO_3)(H_2O)]•4H_2O.

Ba-O(1)	2.9183(17)
Ba-O(1)#1	2.9182(17)
Ba-O(2)	2.8372(17)
Ba-O(2)#1	2.8372(17)
Ba-O(3)#1	2.8631(17)
Ba-O(3)	2.8631(17)
Ba-O(7)	2.681(3)
Ba-N(1)#1	3.049(2)
Ba-N(1)	3.049(2)
Ba-N(2)#1	2.973(2)
Ba-N(2)	2.973(2)
S-O(4)	1.4500(19)
S-O(5)	1.4619(17)
S-O(6)	1.4629(17)
S-C(12)	1.775(3)
O(1)-C(2)	1.430(3)
O(1)-C(3)	1.429(3)
O(2)-C(4)	1.439(3)
O(2)-C(5)	1.415(3)
O(3)-H(3)	0.80(2)
O(3)-C(15)	1.349(3)
O(7)-H(7)	0.85(2)
O(7)-H(7)#1	0.85(2)
N(1)-C(1)	1.478(3)
N(1)-C(6)	1.477(3)
N(1)-C(7)	1.461(3)
N(2)-C(8)	1.322(3)
N(2)-C(16)	1.363(3)
C(1)-H(1A)	0.9900
C(1)-H(1B)	0.9900
C(1)-C(2)	1.503(4)
C(2)-H(2A)	0.9900
C(2)-H(2B)	0.9900
C(3)-H(3A)	0.9900

C(3)-H(3B)	0.9900
C(3)-C(4)#1	1.496(4)
C(4)-H(4A)	0.9900
C(4)-H(4B)	0.9900
C(5)-H(5A)	0.9900
C(5)-H(5B)	0.9900
C(5)-C(6)	1.516(4)
C(6)-H(6A)	0.9900
C(6)-H(6B)	0.9900
C(7)-H(7A)	0.9900
C(7)-H(7B)	0.9900
C(7)-C(8)	1.510(3)
C(8)-C(9)	1.412(4)
C(9)-H(9)	0.9500
C(9)-C(10)	1.362(4)
C(10)-H(10)	0.9500
C(10)-C(11)	1.420(3)
C(11)-C(12)	1.426(4)
C(11)-C(16)	1.419(4)
C(12)-C(13)	1.371(3)
C(13)-H(13)	0.9500
C(13)-C(14)	1.408(4)
C(14)-H(14)	0.9500
C(14)-C(15)	1.371(4)
C(15)-C(16)	1.437(3)
O(11)-H(11A)	0.84(2)
O(11)-H(11B)	0.83(2)
O(10)-H(10A)	0.83(2)
O(10)-H(10B)	0.84(2)
O(8)-H(8A)	0.84(2)
O(8)-H(8B)	0.82(2)
O(9)-H(9A)	0.84(3)
O(9)-H(9B)	0.85(3)

O(1)#1-Ba-O(1)	141.01(8)
O(1)-Ba-N(1)#1	114.74(5)

O(1)-Ba-N(1)	59.62(5)
O(1)#1-Ba-N(1)#1	59.62(5)
O(1)#1-Ba-N(1)	114.74(5)
O(1)#1-Ba-N(2)#1	74.33(6)
O(1)-Ba-N(2)	74.33(6)
O(1)-Ba-N(2)#1	137.83(5)
O(1)#1-Ba-N(2)	137.84(5)
O(2)#1-Ba-O(1)#1	106.32(5)
O(2)-Ba-O(1)#1	57.58(5)
O(2)#1-Ba-O(1)	57.58(5)
O(2)-Ba-O(1)	106.32(5)
O(2)-Ba-O(2)#1	135.05(9)
O(2)#1-Ba-O(3)	71.63(5)
O(2)-Ba-O(3)	150.48(5)
O(2)#1-Ba-O(3)#1	150.48(5)
O(2)-Ba-O(3)#1	71.63(5)
O(2)#1-Ba-N(1)	116.16(6)
O(2)-Ba-N(1)#1	116.16(6)
O(2)#1-Ba-N(1)#1	57.26(5)
O(2)-Ba-N(1)	57.26(5)
O(2)-Ba-N(2)	97.17(5)
O(2)#1-Ba-N(2)	114.52(5)
O(2)-Ba-N(2)#1	114.52(5)
O(2)#1-Ba-N(2)#1	97.17(5)
O(3)#1-Ba-O(1)#1	75.63(5)
O(3)#1-Ba-O(1)	137.11(5)
O(3)-Ba-O(1)#1	137.11(5)
O(3)-Ba-O(1)	75.62(5)
O(3)#1-Ba-O(3)	86.92(7)
O(3)#1-Ba-N(1)#1	103.15(5)
O(3)#1-Ba-N(1)	87.83(5)
O(3)-Ba-N(1)#1	87.83(5)
O(3)-Ba-N(1)	103.15(5)
O(3)-Ba-N(2)	54.32(5)
O(3)-Ba-N(2)#1	63.81(5)
O(3)#1-Ba-N(2)	63.81(5)

O(3)#1-Ba-N(2)#1	54.32(5)
O(7)-Ba-O(1)#1	70.51(4)
O(7)-Ba-O(1)	70.51(4)
O(7)-Ba-O(2)#1	67.52(4)
O(7)-Ba-O(2)	67.52(4)
O(7)-Ba-O(3)#1	136.54(4)
O(7)-Ba-O(3)	136.54(4)
O(7)-Ba-N(1)	82.50(4)
O(7)-Ba-N(1)#1	82.50(4)
O(7)-Ba-N(2)#1	134.90(4)
O(7)-Ba-N(2)	134.90(4)
N(1)#1-Ba-N(1)	164.99(8)
N(2)-Ba-N(1)	55.29(6)
N(2)#1-Ba-N(1)#1	55.29(6)
N(2)#1-Ba-N(1)	138.92(6)
N(2)-Ba-N(1)#1	138.92(6)
N(2)#1-Ba-N(2)	90.21(9)
O(4)-S-O(5)	111.79(11)
O(4)-S-O(6)	113.15(11)
O(4)-S-C(12)	106.84(11)
O(5)-S-O(6)	111.56(10)
O(5)-S-C(12)	106.82(10)
O(6)-S-C(12)	106.19(11)
C(2)-O(1)-Ba	115.32(15)
C(3)-O(1)-Ba	117.91(14)
C(3)-O(1)-C(2)	110.0(2)
C(4)-O(2)-Ba	117.43(15)
C(5)-O(2)-Ba	127.23(15)
C(5)-O(2)-C(4)	114.0(2)
Ba-O(3)-H(3)	119(2)
C(15)-O(3)-Ba	120.31(13)
C(15)-O(3)-H(3)	113(3)
Ba-O(7)-H(7)	133(3)
Ba-O(7)-H(7)#1	133(3)
H(7)-O(7)-H(7)#1	94(6)
C(1)-N(1)-Ba	110.01(14)

C(6)-N(1)-Ba	107.97(14)
C(6)-N(1)-C(1)	109.9(2)
C(7)-N(1)-Ba	110.03(14)
C(7)-N(1)-C(1)	108.4(2)
C(7)-N(1)-C(6)	110.59(19)
C(8)-N(2)-Ba	120.09(16)
C(8)-N(2)-C(16)	117.9(2)
C(16)-N(2)-Ba	117.18(14)
N(1)-C(1)-H(1A)	108.6
N(1)-C(1)-H(1B)	108.6
N(1)-C(1)-C(2)	114.8(2)
H(1A)-C(1)-H(1B)	107.5
C(2)-C(1)-H(1A)	108.6
C(2)-C(1)-H(1B)	108.6
O(1)-C(2)-C(1)	108.8(2)
O(1)-C(2)-H(2A)	109.9
O(1)-C(2)-H(2B)	109.9
C(1)-C(2)-H(2A)	109.9
C(1)-C(2)-H(2B)	109.9
H(2A)-C(2)-H(2B)	108.3
O(1)-C(3)-H(3A)	110.0
O(1)-C(3)-H(3B)	110.0
O(1)-C(3)-C(4)#1	108.4(2)
H(3A)-C(3)-H(3B)	108.4
C(4)#1-C(3)-H(3A)	110.0
C(4)#1-C(3)-H(3B)	110.0
O(2)-C(4)-C(3)#1	108.5(2)
O(2)-C(4)-H(4A)	110.0
O(2)-C(4)-H(4B)	110.0
C(3)#1-C(4)-H(4A)	110.0
C(3)#1-C(4)-H(4B)	110.0
H(4A)-C(4)-H(4B)	108.4
O(2)-C(5)-H(5A)	109.9
O(2)-C(5)-H(5B)	109.9
O(2)-C(5)-C(6)	109.0(2)
H(5A)-C(5)-H(5B)	108.3

C(6)-C(5)-H(5A)	109.9
C(6)-C(5)-H(5B)	109.9
N(1)-C(6)-C(5)	113.5(2)
N(1)-C(6)-H(6A)	108.9
N(1)-C(6)-H(6B)	108.9
C(5)-C(6)-H(6A)	108.9
C(5)-C(6)-H(6B)	108.9
H(6A)-C(6)-H(6B)	107.7
N(1)-C(7)-H(7A)	108.7
N(1)-C(7)-H(7B)	108.7
N(1)-C(7)-C(8)	114.32(19)
H(7A)-C(7)-H(7B)	107.6
C(8)-C(7)-H(7A)	108.7
C(8)-C(7)-H(7B)	108.7
N(2)-C(8)-C(7)	118.9(2)
N(2)-C(8)-C(9)	122.4(2)
C(9)-C(8)-C(7)	118.5(2)
C(8)-C(9)-H(9)	119.9
C(10)-C(9)-C(8)	120.2(2)
C(10)-C(9)-H(9)	119.9
C(9)-C(10)-H(10)	120.4
C(9)-C(10)-C(11)	119.3(2)
C(11)-C(10)-H(10)	120.4
C(10)-C(11)-C(12)	124.4(2)
C(16)-C(11)-C(10)	116.4(2)
C(16)-C(11)-C(12)	119.2(2)
C(11)-C(12)-S	120.60(18)
C(13)-C(12)-S	119.40(19)
C(13)-C(12)-C(11)	120.0(2)
C(12)-C(13)-H(13)	119.5
C(12)-C(13)-C(14)	121.0(2)
C(14)-C(13)-H(13)	119.5
C(13)-C(14)-H(14)	119.6
C(15)-C(14)-C(13)	120.8(2)
C(15)-C(14)-H(14)	119.6
O(3)-C(15)-C(14)	123.8(2)

O(3)-C(15)-C(16)	116.5(2)
C(14)-C(15)-C(16)	119.7(2)
N(2)-C(16)-C(11)	123.5(2)
N(2)-C(16)-C(15)	117.3(2)
C(11)-C(16)-C(15)	119.2(2)
H(11A)-O(11)-H(11B)	102(4)
H(10A)-O(10)-H(10B)	108(3)
H(8A)-O(8)-H(8B)	106(3)
H(9A)-O(9)-H(9B)	105(4)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,-y+1,z

2.3 Potentiometric Titration Curves and Species Distribution Plots

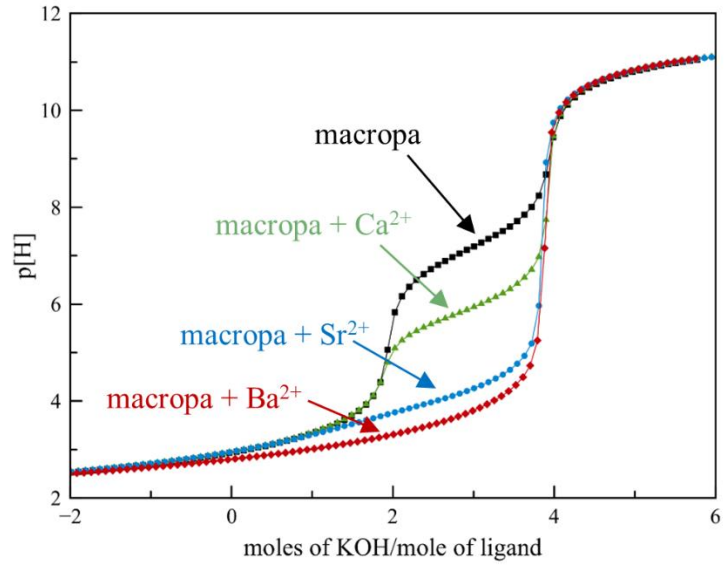


Figure S15. Potentiometric titration curves for macropa (1 mM) in the presence and absence of 1 equiv of Ca^{2+}, Sr^{2+}, or Ba^{2+}. I = 0.1 M KCl, 25 °C.

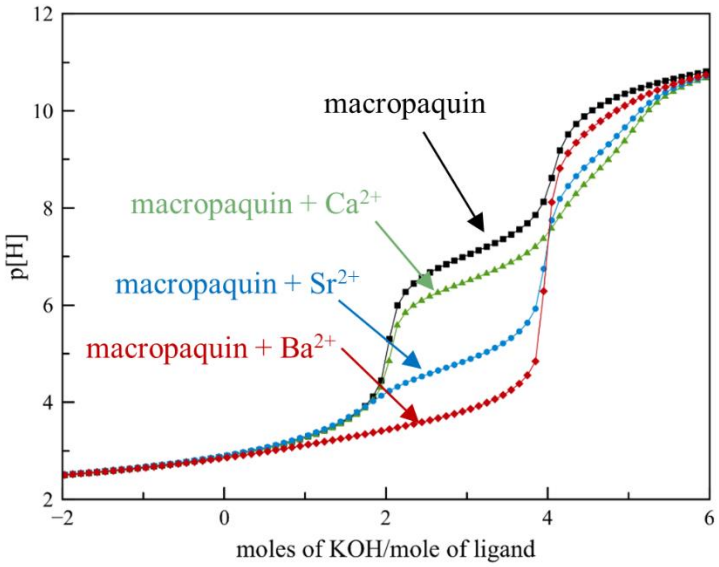


Figure S16. Potentiometric titration curves for macropaquin (1 mM) in the presence and absence of 1 equiv of Ca^{2+}, Sr^{2+}, or Ba^{2+}. I = 0.1 M KCl, 25 °C.

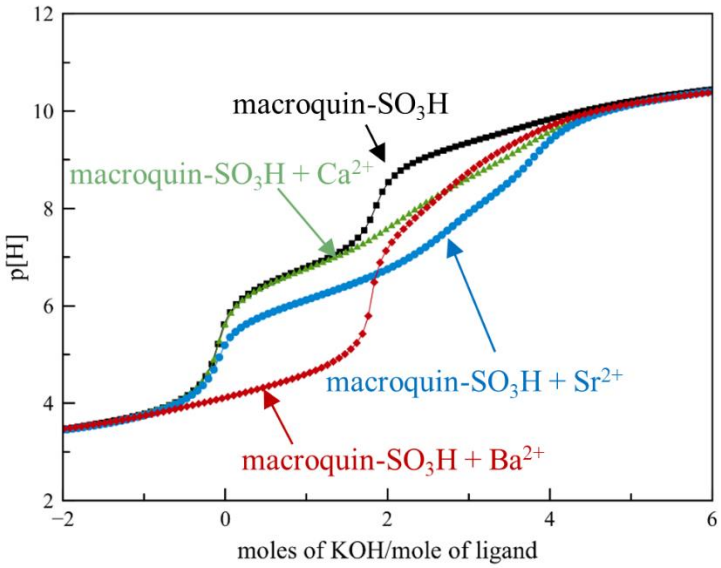


Figure S17. Potentiometric titration curves for macroquin-SO_3 (0.2 mM) in the presence and absence of 1 equiv of Ca^{2+}, Sr^{2+}, or Ba^{2+}. I = 0.1 M KCl, 25 °C.

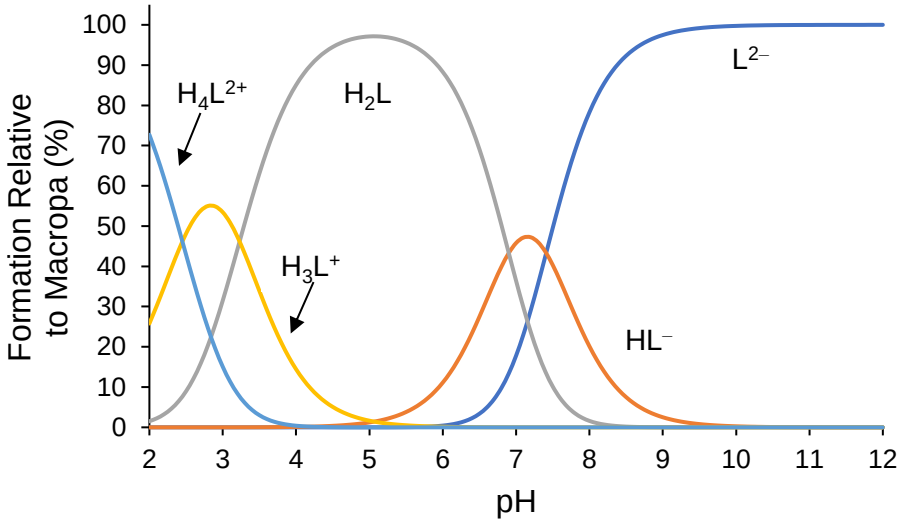


Figure S18. Species distribution diagram of the macropa system. L = 1 mM, I = 0.1 M KCl, 25 °C.

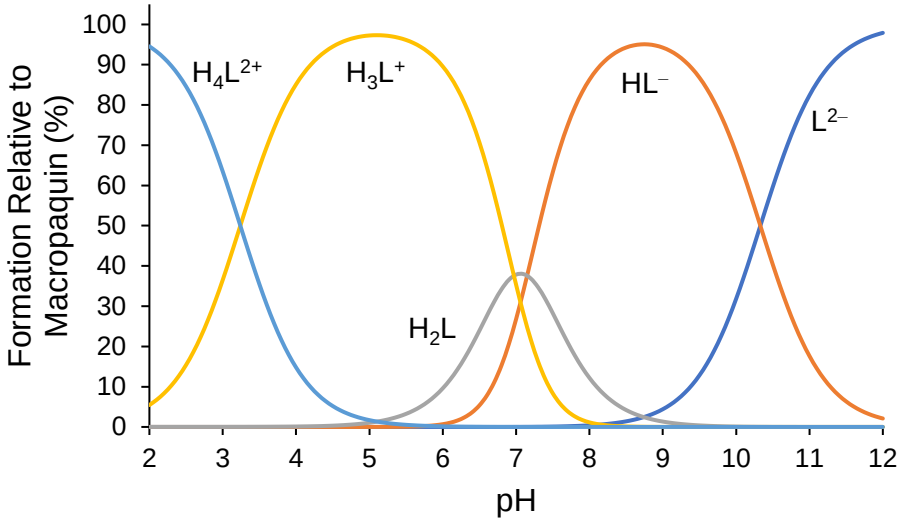


Figure S19. Species distribution diagram of the macropaquin system. L = 1 mM, I = 0.1 M KCl, 25 °C.

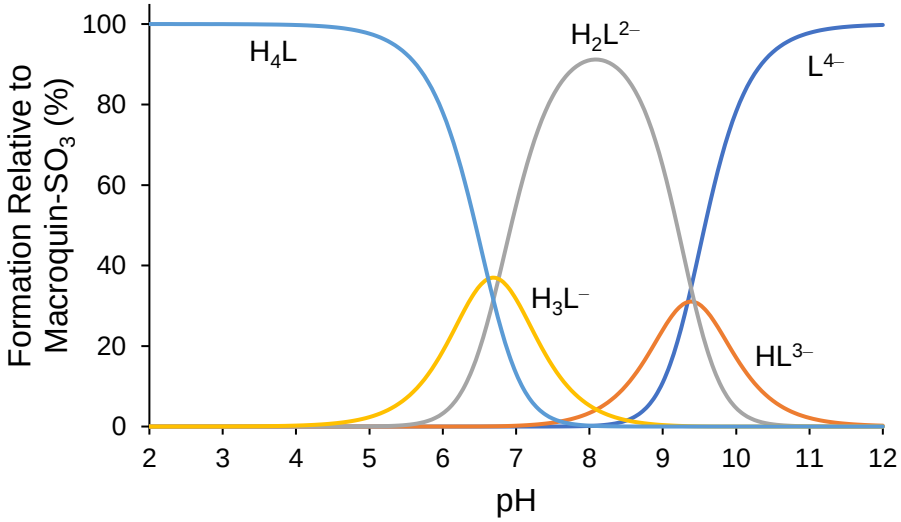


Figure S20. Species distribution diagram of the macroquin-SO_3 system. L = 1 mM, I = 0.1 M KCl, 25 °C.

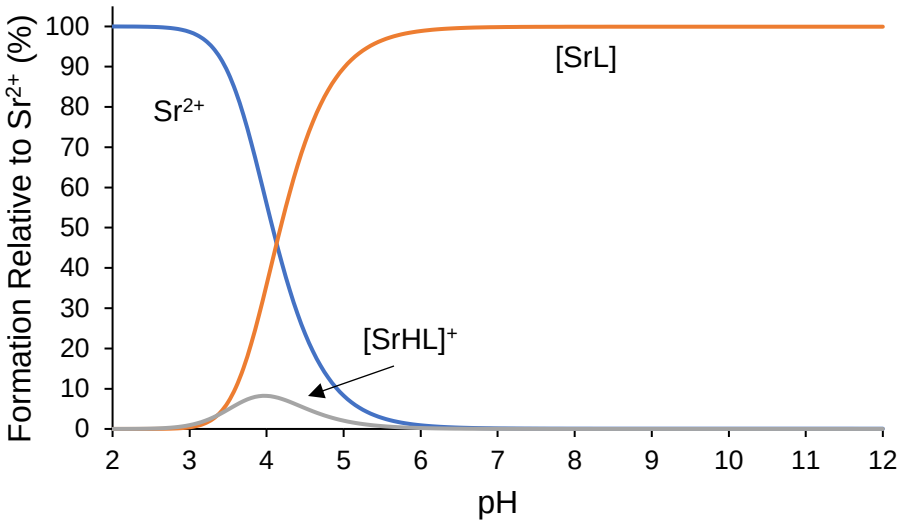


Figure S21. Species distribution diagram of the Sr–macropa system. 1:1 M:L, M^{2+} = 1 mM, I = 0.1 M KCl, 25 °C.

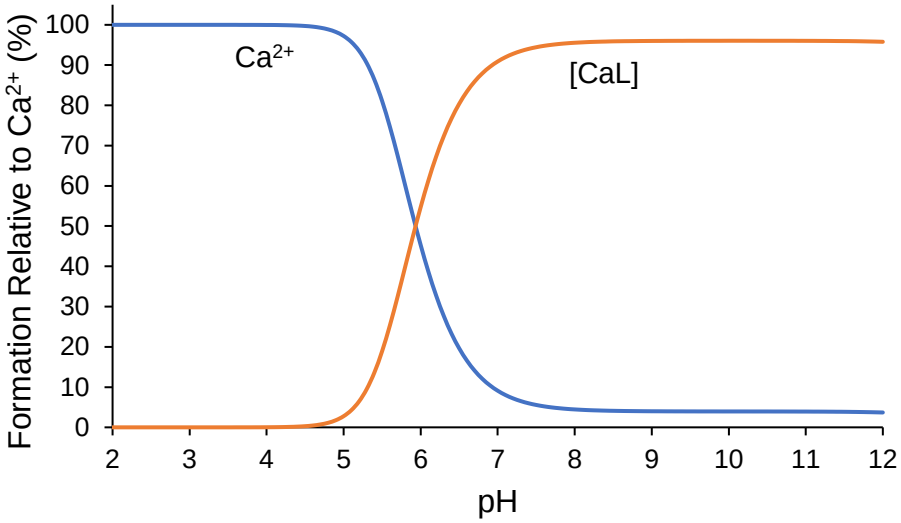


Figure S22. Species distribution diagram of the Ca–macropa system. 1:1 M:L, M^{2+} = 1 mM, I = 0.1 M KCl, 25 °C.

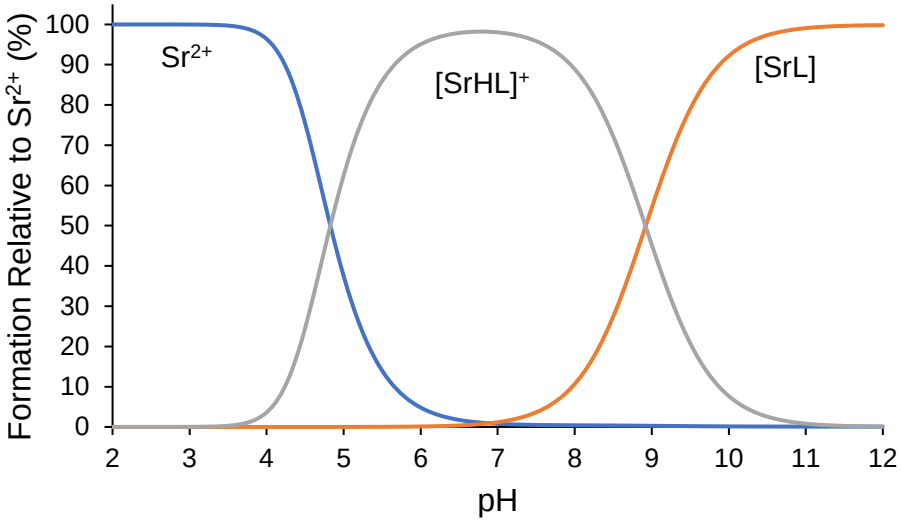


Figure S23. Species distribution diagram of the Sr–macropaquin system. 1:1 M:L, M^{2+} = 1 mM, I = 0.1 M KCl, 25 °C.

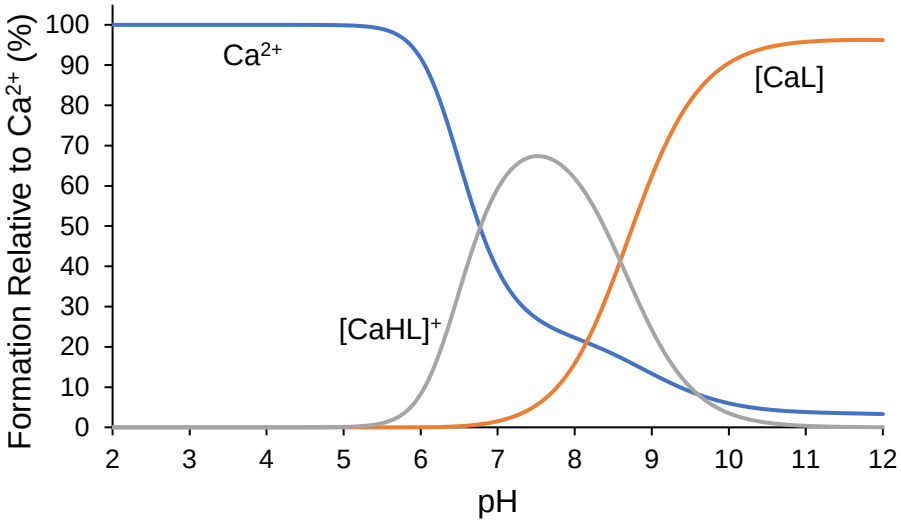


Figure S24. Species distribution diagram of the Ca–macropaquin system. 1:1 M:L, M^{2+} = 1 mM, I = 0.1 M KCl, 25 °C.

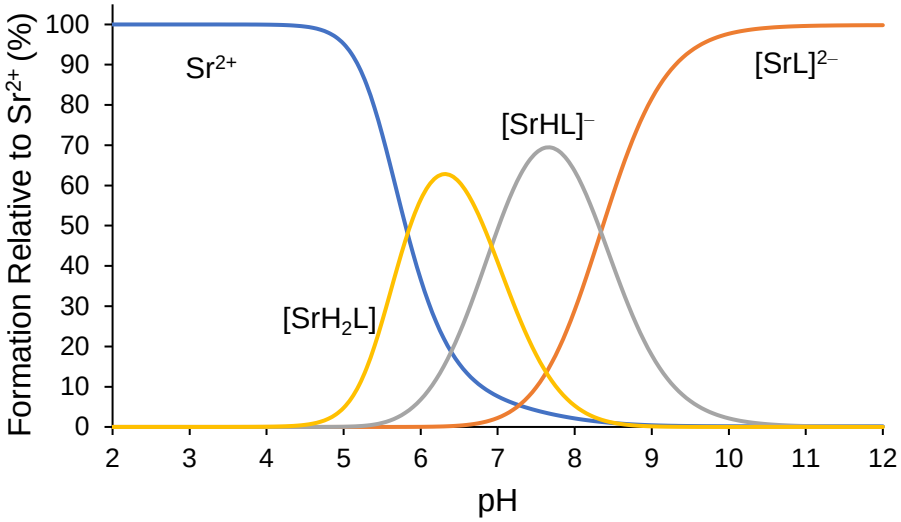


Figure S25. Species distribution diagram of the Sr–macroquin-SO_3 system. 1:1 M:L, M^{2+} = 1 mM, I = 0.1 M KCl, 25 °C.

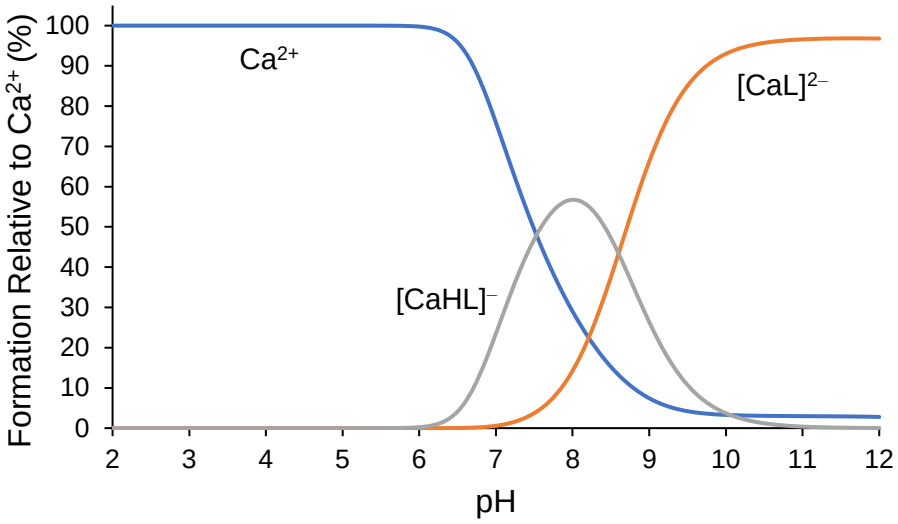


Figure S26. Species distribution diagram of the Ca–macroquin-SO_3 system. 1:1 M:L, M^{2+} = 1 mM, I = 0.1 M KCl, 25 °C.

2.4 Complex Stability: Transmetalation Studies

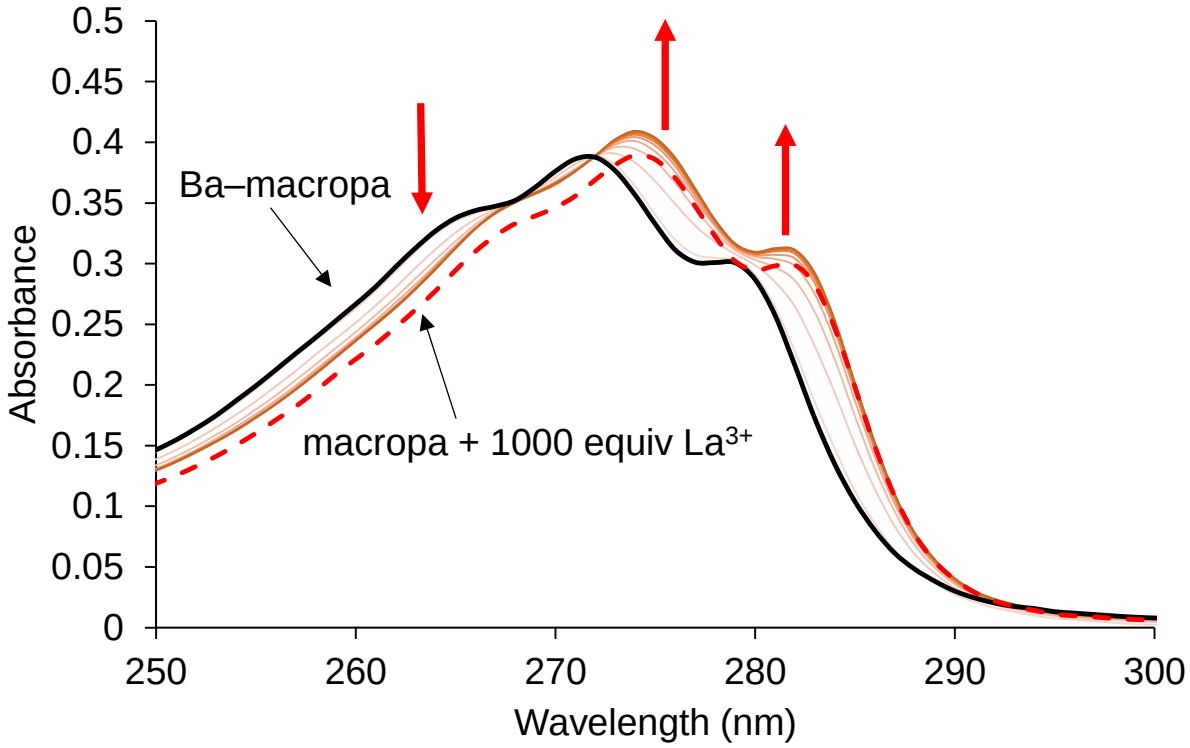


Figure S27. Transmetalation of Ba–macropa by La^{3+}. The kinetic stability of Ba–macropa was assessed by UV-vis spectroscopy in MOPS buffer (pH 7.3) at RT in the presense of 1000-fold excess of La^{3+}, a competing metal ion. Under these conditions, Ba–macropa underwent transmetalation with a half-life of 5.45 ± 0.20 min. The final spectrum matched that of La–macropa.

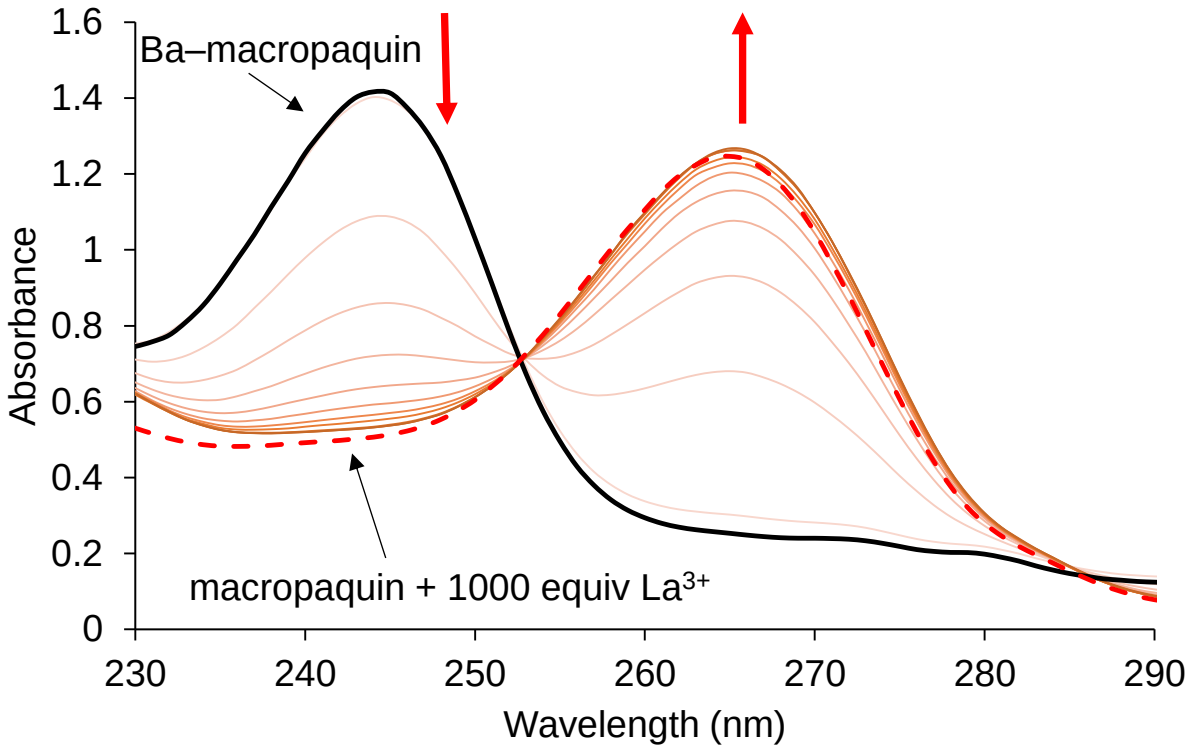


Figure S28. Transmetalation of Ba–macropaquin by La^{3+}. The kinetic stability of Ba–macropaquin was assessed by UV-vis spectroscopy in MOPS buffer (pH 7.3) at RT in the presense of 1000-fold excess of La^{3+}, a competing metal ion. Under these conditions, Ba–macropaquin underwent transmetalation with a half-life of 6.07 ± 0.13 min. The final spectrum matched that of La–macropaquin.

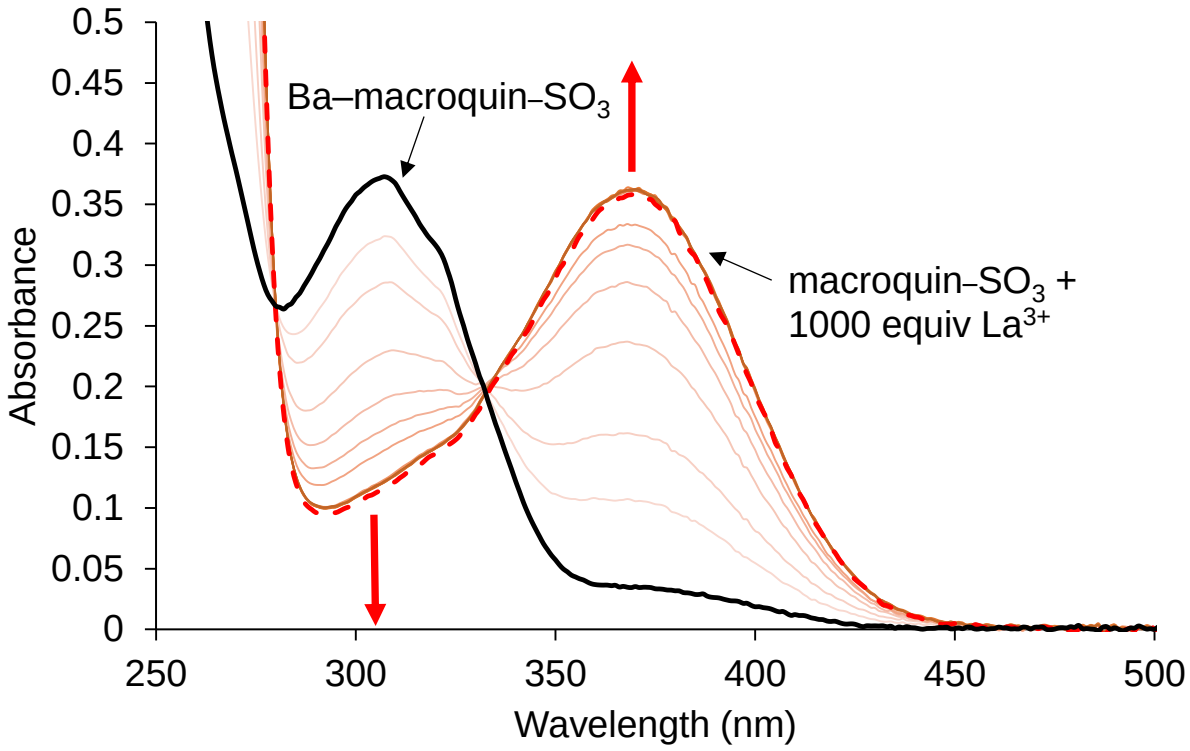


Figure S29. Transmetalation of Ba–macroquin–SO_3 by La^{3+}. The kinetic stability of Ba–macroquin–SO_3 was assessed by UV-vis spectroscopy in MOPS buffer (pH 7.3) at RT in the presense of 1000-fold excess of La^{3+}, a competing metal ion. Under these conditions, Ba–macroquin–SO_3 underwent transmetalation with a half-life of 0.65 ± 0.05 min. The final spectrum matched that of La–macroquin–SO_3.

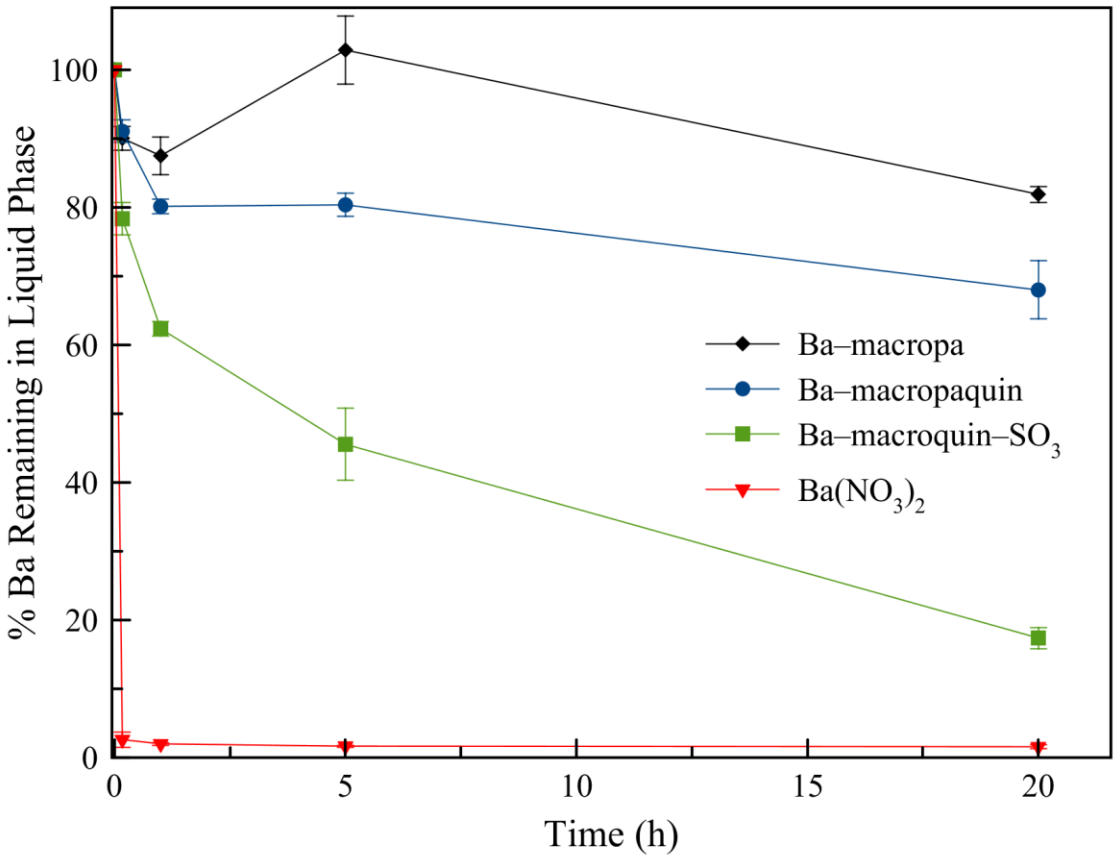


Figure S30. Hydroxyapatite challenge. Barium complexes of macropa, macropaquin, and macroquin–SO_3 were stirred at RT in the presence of HAP (50 mg). The suspensions were filtered after 10 min, 1 h, 5 h, or 20 h, and the filtrate was analyzed by GFAAS to determine the amount of barium remaining in the liquid phase, reflecting intact Ba–L complex. The order of stability of the complexes was Ba–macropa > Ba–macropaquin >> Ba–macroquin–SO_3. Free barium ($Ba(NO_3)_2$) is rapidly adsorbed by HAP in the absence of ligand.

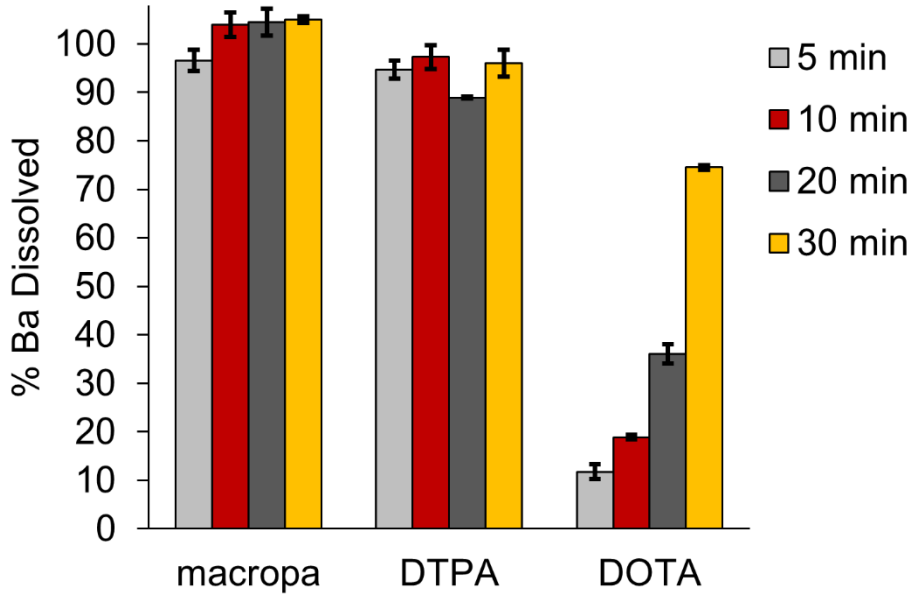


Figure S31. Dissolution of $BaSO_4$ by macropa, DOTA, and DTPA at pH 11. Dissolution at RT and pH 11 was initiated by the addition of chelator (5 mM) to a suspension of $BaSO_4$ (4.53 mM $Ba(NO_3)_2$ and 13.48 mM Na_2SO_4). Barium content in solution was measured by GFAAS after 5, 10, 20, and 30 min.

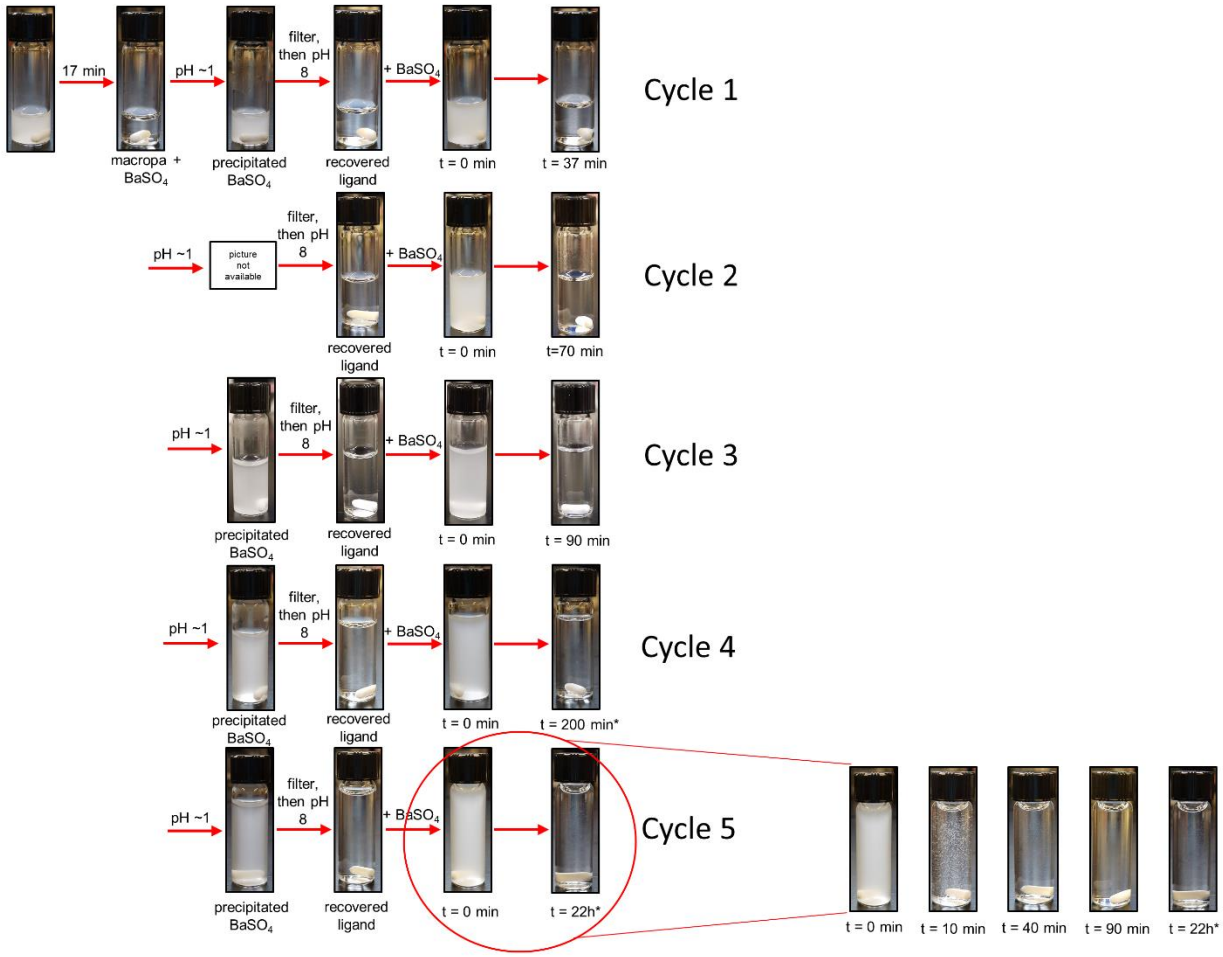


Figure S32. Ligand recovery and reuse. A solution of macropa-dissolved $BaSO_4$ (9.66 mM macropa, 8.74 mM Ba^{2+}, 26.04 mM SO_4^{2-}) was acidified with conc. HCl to release the Ba^{2+} from the ligand as $BaSO_4$. After filtration of the precipitated $BaSO_4$ and basification of the solution using 2 M NaOH, the recovered ligand was reused to dissolve another portion of $BaSO_4$ (0.009 mmol $BaNO_3$, 0.027 mmol Na_2SO_4). The ligand was recycled from the initial macropa-dissolved $BaSO_4$ solution a total of 5 times. The amount of time required for complete $BaSO_4$ dissolution, indicated by the absence of visible precipitate in the vial, was recorded. An asterick (*) indicates that a slight precipitate still persisted beyond the time indicated, which marks the point at which the last picture was taken. *Inset:* After 5 cycles of recovery and reuse, macropa is still able to rapidly dissolve $BaSO_4$; dissolution is nearly complete within 90 min.

3. REFERENCES

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