Syntheses of Diazadithiacrown Ethers Containing Appended Coumarin or 1-Aminonaphthalene Sidearms

Hua-Can Song* [a], Yi-Wen Chen [b], Jun-Hua Yao [b], Zun-Le Xu [a], Jerald S. Bradshaw [c], Paul B. Savage [c] and Reed M. Izatt [c]

[a] Department of Chemistry, [b] Center of Analysis and Measurement, Zhongshan University, Guangzhou 510275 P. R. China; [c] Department of Chemistry and Biochemistry, Brigham Young University, Provo, UT 84602 USA

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Six crown ethers containing two coumarin (**11**, **13**, **14**, **16**, **17** and **19**) or two 1-aminonaphthalene (**15** and **20**) fragments as sidearms and two crown ethers bearing one coumarin (**12** and **18**) arm were synthesized by a nucleophilic substitution of the secondary macrocyclic amine function on the alkyl halide. The major products of these reactions were the diazadithiacrown ethers containing two sidearms. In some cases, one-armed diazadithiacrown ethers were separated as minor products, although more than 2.5 mmoles of alkyl halide were used for 1.0 mmole of macrocyclic diamine.

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Introduction.

The toxicities of many transition and post-transition metal ions are well recognized [1]. As a result, much attention has been paid to controlling contamination of water supplies by toxic metal ions and to monitoring their levels in the environment [2]. Traditional methods of measuring metal ion concentrations in waste steams are usually spectroscopic and wet chemical analysis techniques on samples removed from the waste steams [3]. An attractive alternative to these methods would be to monitor the concentrations of specific metal ions in a complex matrix continuously and remotely by using ion-selective sensory devices. Ion-selective chemo sensors may play a central role in developing such devices.

Numerous ion-selective chemo sensors, based on synthetic fluoroionophores, have been reported [4-13]. For example, Bradshaw and his co-workers found that crown ethers containing 8-hydroxyquinoline fragments as sidearms (**1**-**3**, Figure 1) are excellent Mg^{2+}, Ba^{2+} or Hg^{2+} ion-selective chemo sensors [14-16]. It was also reported recently that a crown ether bearing a coumarin sidearm (**4**, Figure 1) showed an excellent selectivity for Pb^{2+} [17].

It is well known that the complexing ability and selectivity of lariat ethers for metal ions can be changed by varying certain parameters, such as the size of the crown ether ring and the type, number and position of the ring complexing heteroatoms [10,18-20]. Sulfur atoms have a high affinity and selectivity for Pb^{2+} and Hg^{2+}. Therefore,

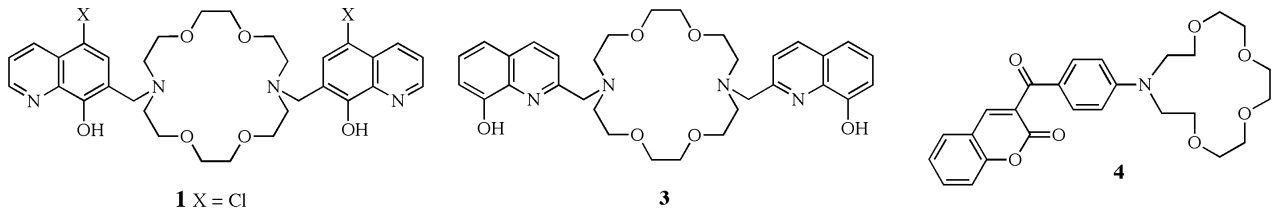
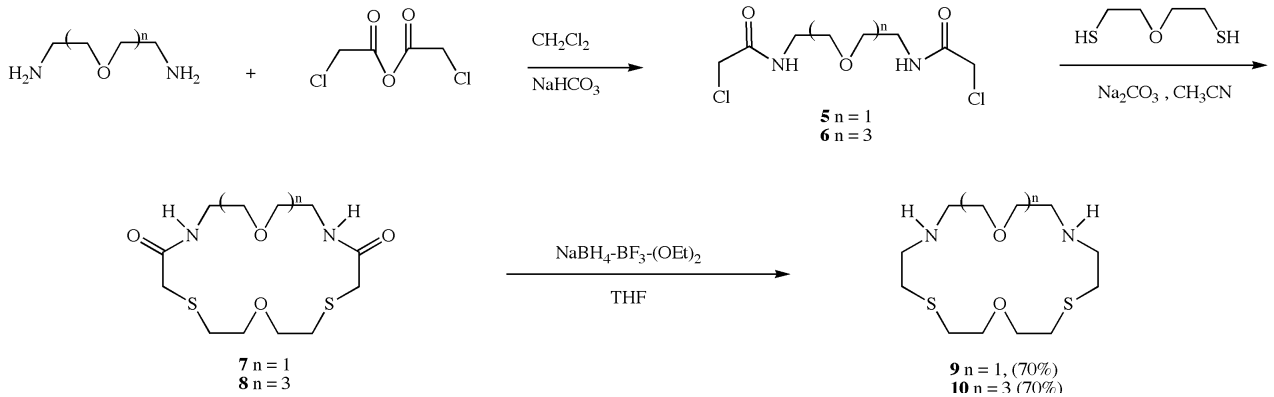


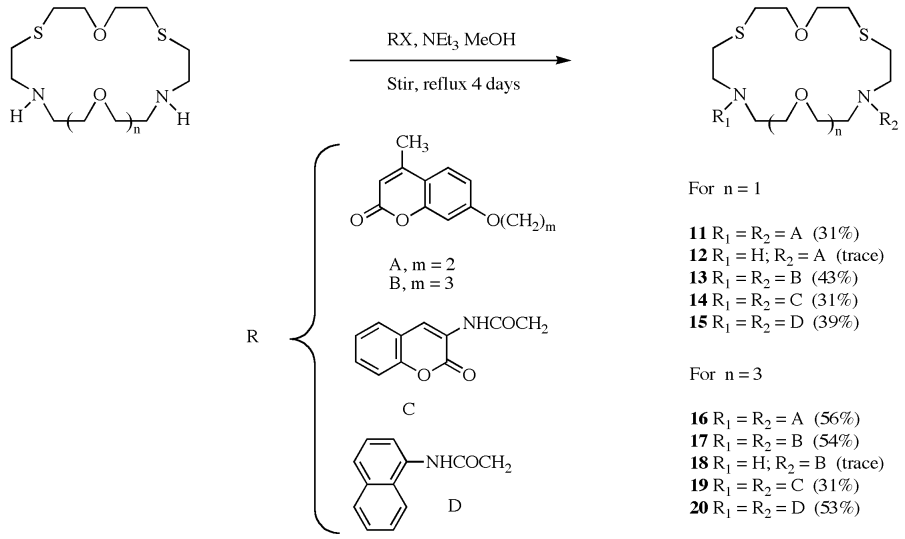
Figure 1. 8-Hydroxyquinoline and Coumarin-substituted Ligands Mentioned in the Introduction.

Scheme 1



adding to our previous work [7-9,11,12], we report herein the synthesis of 10 diazadithiacrown ethers containing 18 and 24 ring members, which bear coumarin or 1-aminonaphthalene sidearms (**11**-**20**, Scheme 2).

Scheme 2



Results And Discussion.

Dichlorodiamide starting materials **5** and **6** were synthesized by the reaction of chloroacetic anhydride or chloroacetyl chloride with the appropriate diamine (Scheme 1). Macrocyclic diamides **7** and **8** (58%) were prepared by treating the appropriate dichlorodiamide with 3-oxa-1,5-pentanedithiol. The cyclic amides were reduced in good yields using $NaBH_4$-BF_3-$(OEt)_2$ in THF to form the corresponding secondary macrocyclic diamines **9** (70%) and **10** (70%) as reported [7-9,11].

The preparation of ligands **11-20** (Scheme 2) was accomplished by nucleophilic substitution by the appropriate macrocyclic secondary amine on the corresponding alkyl halide where X = bromide or chloride. A solution of the macrocyclic diamine, the appropriate alkyl halide and triethylamine in methanol was refluxed for 4 days. The desired compounds were separated from the reaction mixture by chromatography on a silica gel column. Initially, 2.2 eq. of the corresponding alkyl halide were used. A small amount of one-armed by-product was isolated in two instances from these reaction mixtures; however, the yield of the two-armed product was unsatisfactory. Using 2.5-3.0 eq. of alkyl halide and increasing the reaction time from one day to four days gave satisfactory yields of the two-armed product along with a minor amount of the one-armed by-product. Acetonitrile is usually used in this type of nucleophilic substitution reaction [7]; however, because the solubility of many of our starting materials was very low in acetonitrile, methanol was used as the solvent in this study. In addition, the product mixtures were complex and the desired compounds were difficult to isolate and purify when acetonitrile was used as the solvent. When methanol was used, the reaction mixtures were less complex and the major products were easier to isolate and purify.

Intermediates **21** and **22** (Scheme 3) were prepared in a straight-forward manner by treating 4-methyl-7-hydroxycoumarin with 1.5 eq. of 1,2-dichloroethane or 1,3-dibromopropane in the presence of sodium hydroxide. Compounds **23** and **24** were synthesized by the reaction of chloroacetyl chloride with the appropriate aromatic amine in the presence of sodium acetate. Preparation of **23** and **24** required synthesis of 3-aminocoumarin. After investigating published methods [21-23], we found that if equivalent amounts of salicylaldehyde and methyl aminoacetate hydrochloride were reacted in water at pH 8-9, 3-aminocoumarin was formed in 84% yield. In addition, the desired compound was easily purified by recrystallization from the reaction residue.

The structures of all new macrocyclic compounds were consistent with data obtained from ^1H and ^{13}C nmr spectral analyses and ms analyses. In addition, the new macrocycles containing sidearms (**11**-**20**) exhibited satisfactory elemental analyses or hrms molecular weights.

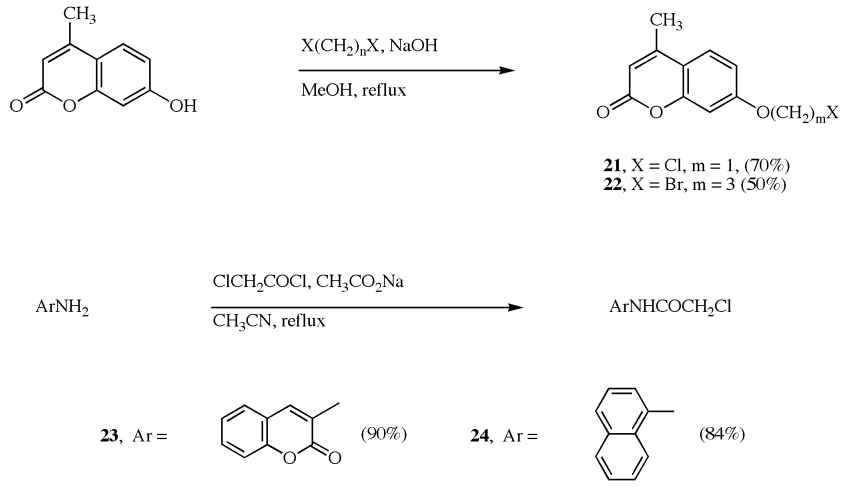
EXPERIMENTAL

All starting materials were used as purchased from commercial sources. Macrocyclic diamine **7** was prepared as reported [8].

7-(2-Chloroethoxy)-4-methylcoumarin (**21**) (Scheme 3).

4-Methyl-7-hydroxycoumarin (8.80 g, 50.0 mmole) and sodium hydroxide (2.0 g, 50.0 mmole) were dissolved in 200 mL of methanol. 1,2-Dichloroethane, (7.92 g, 6.4 mL 80.0 mmole) was added and the mixture was refluxed for 3 days. The solvent

Scheme 3



was evaporated under reduced pressure and the residue was separated by silica gel chromatography using chloroform as eluent to give 8.35 g (70%) of **21**, mp 103-104°; ^{1}H nmr: δ 2.41 (s, 3H), 3.87 (t, *J* = 5.6 Hz, 2H), 4.30 (t, *J* = 5.8 Hz, 2H), 6.16 (s, 1H), 6.82 (d, *J* = 2.6 Hz, 1H), 6.89 (dd, J_1 = 8.8 Hz, J_2 = 2.4 Hz, 1H), 7.51(d, *J* = 8.8 Hz, 1H); ^{13}C nmr: δ 19.1, 42.0, 68.8, 102.1, 112.7, 113.0, 114.6, 126.2, 152.9, 155.6, 161.6; ms (fab) for $C_{12}H_{12}N_2O_3Cl$ $(M+H)^+$, calcd. 239.0, found 239.0.

7-(3-Bromopropoxy)-4-methylcoumarin (**22**) (Scheme 3).

Compound **22** (2.97 g, 50%) was prepared as above from 3.52 g (20.0 mmole) of 4-methyl-7-hydroxycoumarin and 6.46 g (32.0 mmole) of 1,3-dibromopropane; mp 82-83°; ^{1}H nmr: δ 2.32-2.38 (m, 2H), 2.40 (s, 3H), 3.61 (t, *J* = 6.4 Hz, 2H), 4.17 (t, *J* = 5.7 Hz, 2H), 6.13 (s, 1H), 6.81 (d, *J* = 2.5 Hz, 1 H), 6.85 (dd, J_1 = 8.7 Hz, J_2 = 2.4 Hz, 1H), 7.48 (d, *J* = 8.7 Hz, 1H); ^{13}C nmr: δ 19.1, 30.1, 32.4, 66.3, 102.0, 112.5, 112.8, 114.2, 126.1, 153.0, 155.6, 161.7, 162.1; ms (fab) for $C_{13}H_{14}O_3Br$ $(M+H)^+$, calcd. 297.0, found 297.0.

3-Aminocoumarin.

Salicylaldehyde (12.2 g, 0.10 mole) and 12.6 g (0.10 mole) of methyl aminoacetate hydrochloride were mixed and the pH value of the mixture was adjusted to 8-9 using triethylamine. The resulting mixture was heated to 80-90° for 30 minutes. The mixture was allowed to cool to room temperature and stirring was continued until a precipitate formed. The crude product was isolated by filtration and washed with water. The solid was recrystallized from ethanol to give 13.36 g (83%) of a white solid product; mp 127-128° [literature 132-133°] [24].

3-(Chloromethylformylamino)coumarin (**23**) (Scheme 3).

3-Aminocoumarin (4.83 g, 30.0 mmole) and 4.92 g (45.0 mmole) of anhydrous sodium acetate was dissolved in 100 mL of dried acetonitrile and the mixture was cooled on an ice-bath. Chloroacetyl chloride (3.39 g, 30.0 mmole) was added dropwise to the mixture. The mixture was allowed to warm to room temperature and stirring was continued for 10 minutes. The solvent was evaporated under reduced pressure and the residue was washed with water. The desired product was separated by silica gel chromatography to give 6.40 g (90%) of a white solid; mp 238-239°; ^{1}H nmr: δ 4.23 (s, 2H), 7.33-7.35 (m, 1H), 7.36 (d, *J* = 3.7 Hz, 1H), 7.48 (dd, J_1 = 8.0 Hz, J_2 = 1.5 Hz, 1H), 7.54 (dd, J_1 = 8.0 Hz, J_2 = 1.5 Hz, 1H), 8.70 (s, 1H), 9.14(s, 1H, NH); ^{13}C nmr: δ 43.2, 117.0, 119.8, 123.7, 124.6, 125.7, 128.5, 130.7, 150.7, 158.8, 165.7; ms (fab) for $C_{11}H_9NO_3Cl$ $(M+H)^+$, calcd. 238.0, found 238.0.

1-(Chloromethylformylamino)naphthalene (**24**) (Scheme 3).

Compound **24** (18.4 g, 84%) was prepared as above for **23** from 14.32 g (10.0 mmole) of 1-aminonaphthalene and 11.30 g (10.0 mmole, 11.30 g) of chloroacetyl chloride; mp 155-156°; ^{1}H nmr: δ 4.37 (s, 2H), 7.45-7.63 (m, 3H), 7.76 (d, *J* = 8.3 Hz, 1H), 7.88-7.93 (m, 2H), 7.99 (d, *J* = 7.4 Hz, 1H), 8.80 (s, 1H); ^{13}C nmr: δ 43.8, 120.6, 121.0, 126.1, 126.7, 126.9, 127.2, 129.3, 148.2, 153.2, 165.5; ms (fab) for $C_{12}H_{11}NOCl$ $(M+H)^+$, calcd. 220.0, found 220.0.

1,13-Diaza-4,7,10,19-tetraoxa-16,22-dithiacyclotetracosane-14,24-dione (**8**) (Scheme 1).

Macrocyclic diamide **8** was prepared as a viscous liquid (7.10 g, 58%) as in reference [8] from 10.32 g (30.0 mmole) of dichlorodiamide **6** and 4.14 g (30.0 mmole) of 2,2'-oxydiethanethiol; ^{1}H nmr: δ 2.79 (t, *J* = 5.9 Hz, 4H), 3.31 (s, 4H), 3.50 (q, *J* = 5.7 Hz, 4H), 3.58 (t, *J* = 4.8 Hz, 4H), 3.71-3.62 (m, 12 H), 7.48(s, 2H), ^{13}C nmr: δ 34.2, 38.1, 41.2, 71.4, 72.0, 72.2, 72.3, 170.6; ms (fab) for $C_{16}H_{31}N_2O_6S_2$ $(M+H)^+$, calcd. 411.2, found 411.2; hrms for $C_{16}H_{31}N_2O_6S_2$ $(M+H)^+$: calcd. 411.1623, found 411.1631.

1,7-Diaza-4,13-dioxa-10,16-dithiacyclootadecane (**9**) (Scheme 1).

Compound **7** (4.0 g, 12.4 mmole) and 1.51 g (40.0 mmole) of sodium borohydride were dissolved in 300 mL of dried tetrahydrofuran. The mixture was cooled on an ice-bath, 16.1 mL (60.0 mmole) of boron trifluoride etherate was added dropwise at 0-5° and the mixture was allowed to warm to room temperature. The mixture was refluxed for 5 days and most of the tetrahydrofuran was evaporated under reduced pressure. Water (50 mL) was added to the mixture and the solid salt was filtered. The mixture was neutralized with 20% aqueous sodium hydroxide to pH = 8. The tetrahydrofuran in the mixture was removed by evaporation

in vacuum. The product was extracted with chloroform and the solvent was evaporated under reduced pressure. The residue was separated by chromatography on a silica gel column using $CHCl_3$:CH_3OH:$NH_3.H_2O$ = 100:5:0.5 as eluent to give 2.56 g (70%) of viscous liquid **9**; ^{1}H nmr: δ 2.29 (s, 2H), 2.71-2.82 (m, 16H), 3.58 (t, *J* = 4.8 Hz, 4H), 3.69 (t, *J* = 5.4 Hz, 4H); ^{13}C nmr: δ 32.1, 33.2, 48.5, 49.1, 70.1, 71.9; hrms for $C_{12}H_{27}N_2O_2S_2$ $(M+H)^+$, calcd. 295.1566, found 295.1515.

1,13-Diaza-4,7,10,19-tetraoxa-16-22-dithiacyclotetracosane (**10**) (Scheme 1).

Macrocyclic diamine **10**, (2.69 g, 70%), was prepared as a viscous liquid from 4.10 g (10.0 mmole) of macrocyclic diamide **8** as above; ^{1}H nmr: δ 2.80 (t, *J* = 5.9 Hz, 4H), 3.31 (s, 4H), 3.50 (q, *J* =5.1 Hz, 4H), 3.57-3.61 (m, 4H), 3.63-3.71 (m, 16H), 7.48 (s, 2H); ^{13}C nmr: δ 34.2, 38.1, 41.2, 71.5, 72.0, 72.2, 72.3, 73.6; ms (fab) for $C_{16}H_{35}N_2O_4S_2$ $(M+H)^+$, calcd. 383.2, found 383.2; hrms for $C_{16}H_{35}N_2O_4S_2$ $(M+H)^+$, calcd. 383.2038, found 383.2035.

General Procedure for the Preparation of **11**-**20** (Scheme 2).

The macrocyclic diamine (2.0 mmole) and 3.0 mmole of the appropriate alkyl halide were dissolved in 100 mL of methanol and 6.0 mmole of triethylamine was added. The mixture was refluxed for 5 days and the solvent was evaporated under reduced pressure. The residue was chromatographed on silica gel using $CHCl_3$:MeOH:$NH_3.H_2O$ = 100:2:0.2 as eluent to obtain the desired products.

1,7-Bis[2-(4-methyl-7-coumarinyl)oxyethyl]-1,7-diaza-4,13-dioxa-10,16-dithiacyclooctadcane (**11**) (Scheme 2).

According to the general procedure, 0.15 g (31%) of **11** was separated as a yellow viscous liquid from 0.2 g (0.7 mmole) of **9** and 0.50 g (2.1 mmole) of **21**; ^{1}H nmr: δ 2.37 (s, 6H), 2.72-2.81 (m, 8H), 2.85 (t, *J* = 5.5 Hz, 4H), 2.94 (t, *J* = 5.7 Hz, 4H), 3.01 (t, *J* = 5.7 Hz, 4H), 3.60 (t, *J* = 5.5 Hz, 4H), 3.67 (t, *J*= 6.1 Hz, 4H), 4.10 (t, *J* = 5.7 Hz, 4H), 6.11 (s, 2H), 6.78 (d, *J* = 2.4 Hz, 2H), 6.85 (dd, J_1 = 8.8 Hz, J_2= 2.5 Hz, 2H), 7.47 (d, *J* = 8.8 Hz, 2H); ^{13}C nmr: δ 20.3, 31.7, 33.2, 55.3, 55.9, 57.1, 68.8, 71.6, 73.5, 103.1, 113.5, 114.1, 115.2, 127.3, 154.3, 156.8, 162.8, 163.4; ms (fab) for $C_{36}H_{47}N_2O_8S_2$ $(M+H)^+$, calcd. 699.3, found 699.3.

Anal. Calcd. for $C_{36}H_{46}N_2O_8S_2$: C, 61.87; H, 6.63; N, 4.01. Found C, 61.68; H, 6.32; N, 3.92.

1-[2-(4-Methyl-7-coumarinyl)oxyethyl]-1,7-diaza-4,13-dioxa-10,16-dithiacyclooctadecane (**12**) (Scheme 2).

According to the general procedure, compound **15** was isolated as a minor product from the reaction residue in which ligand **11** was obtained; ^{1}H nmr: δ 2.38 (s, 3H), 2.71-2.84 (m, 14H), 2.90 (t, *J* = 5.4 Hz, 2H), 2.98 (t, *J* = 5.5 Hz, 2H), 3.60-3.66 (m, 6H), 3.82 (t, *J* = 4.4 Hz, 2H), 4.09 (t, *J* = 5.42 Hz, 2H), 6.11 (s, 1H), 6.81 (d, *J* = 2.4 Hz, 1H), 6.86 (dd, J_1 = 8.8 Hz, J_2 = 2.5 Hz, 1H), 7.48 (d, *J* = 8.8 Hz, 1H); ^{13}C nmr: δ 20.4, 31.3, 32.8, 33.2, 34.0, 49.4, 50.0, 54.7, 55.4, 56.1, 67.8, 68.5, 70.5, 72.5, 73.7, 103.4, 113.6, 114.1, 115.4, 127.4,154.4, 156.8, 163.0, 163.3; ms (fab) for $C_{24}H_{37}N_2O_5S_2(M+H)^+$, calcd. 497.2; found 497.2. hrms for $C_{24}H_{37}N_2O_5S_2$ $(M+H)^+$, calcd. 497.2144, found 497.2141.

1,7-Bis[3-(4-methyl-7-coumarinyl)oxypropyl]-1,7-diaza-4,13-dioxa-10,16-dithiacyclooctadecane (**13**) (Scheme 2).

Compound **13** (0.22 g, 43%) was obtained as a viscous liquid from 0.20 g (0.7 mmole) of **9** and 0.62 g (2.1 mmole) of **22**; ^{1}H nmr: δ 1.95 (t, *J* = 6.5 Hz, 4H), 2.37 (s, 6H), 2.81-2.63 (m, 24H), 3.65 (t, *J* = 5.5 Hz, 4H), 4.06 (t, *J* = 5.9 Hz, 4H), 6.10 (s, 2H), 6.77 (d, *J* =2.5 Hz, 2H), 6.82 (dd, J_1 = 8.8, J_2 = 2.5 Hz, 2H), 7.46 (d, *J* = 8.8 Hz, 2H); ^{13}C nmr: δ 20.4, 28.6, 31.7, 34.1, 34.2, 52.8, 55.5, 56.6, 68.0, 71.3, 103.0, 113.5, 114.2, 115.2, 127.2, 154.3, 156.9, 163.0, 163.7; ms (fab) for $C_{38}H_{51}N_2O_8S_2$ $(M+H)^+$, calcd. 727.3, found 726.3.

Anal. Calcd. for $C_{38}H_{50}N_2O_8S_2$: C, 62.78; H, 6.93; N, 3.85. Found C, 62.65; H, 6.57; N,3.68.

1,7-Bis(3-coumarinylaminoformylmethyl)-1,7-diaza-4,13-dioxa-10,16-dithiacyclooctadecane (**14**) (Scheme 2).

Ligand **14** (0.15 g, 31%) was obtained from 0.20 g (0.7 mmole) of **9** and 0.50 g (2.1 mmole) of **23**, according to the general procedure; ^{1}H nmr: δ 2.82 (t, *J* = 6.5 Hz, 4H), 2.90 (m, 8H), 3.00 (s, 4H), 3.33 (s, 4H), 3.61 (t, *J* = 4.5 Hz, 4H), 3.74 (t, *J* = 6 Hz, 4H), 7.27 (t, *J* = 7.5 Hz, 2H), 7.29 (d, *J* = 8.0 Hz, 2H), 7.42 (t, *J* = 8.1 Hz, 2H), 7.49 (d, *J* = 7.5 Hz, 2H), 8.68 (s, 2H), 10.05 (s, 2H); ^{13}C nmr δ: 30.0, 31.4, 54.7, 55.8, 59.7, 69.6, 71.9, 116.2, 119.8, 123.3, 123.9, 124.9?127.6, 129.5, 150.2, 158.2, 171.2; ms (fab) for $C_{34}H_{41}N_4O_8S_2(M+H)^+$, calcd. 697.2, found 697.2.

Anal. Calcd. for $C_{34}H_{40}N_4O_8S_2$•CH_3OH: C, 58.13; H, 5.94; N, 7.86. Found C, 58.16;H, 5.53; N, 7.62.

1,7-Bis(1-naphthylaminoformylmethyl)-1,7-diaza-4,13-dioxa-10,16-dithiacyclooctadecane (**15**) (Scheme 2).

Macrocyclic amine **9** (0.20 g, 0.7 mmole) was treated with 2.1 mmole (0.46 g) of chloroacetamide **24** in methanol to give **15** (0.18 g, 39%) as a viscous yellow liquid; ^{1}H nmr: δ 2.63 (s, 4H), 2.73 (t, *J* = 5.6 Hz, 4H), 2.80 (d, *J* = 4.9 Hz, 4H), 2.84 (d, *J* = 4.8 Hz, 4H), 3.27 (s, 4H), 3.49 (t *J* = 5.5 Hz, 4H), 3.67 (t, *J* = 5.6 Hz, 4H), 7.27-7.55 (m, 6H), 7.67 (d, *J* = 8.2 Hz, 2H), 7.84 (d, *J* = 8.2 Hz, 2H), 8.07 (t, *J* = 8.2 Hz, 4H), 10.00 (s, 2H); ^{13}C nmr: δ 31.5, 32.2, 54.7, 55.2, 59.6, 68.8, 71.8, 119.5, 121.4, 125.2, 125.8, 125.9, 126.8, 128.6, 132.6, 134.1, 169.8; ms (fab) for $C_{36}H_{45}N_4O_4S_2$ $(M+H)^+$, calcd. 661.3, found 661.2.

Anal. Calcd. for $C_{36}H_{44}N_4O_4S_2$. H_2O: C, 64.55; H, 6.77; N, 8.36. Found C, 64.84; H, 5.87; N,8.06.

1,13-Bis[2-(4-methyl-7-coumarinyl)oxyethyl]-1,13-diaza-4,7,10,19-tetraoxa-16,22-dithiacyclotetracosane (**16**).

According to the general procedure, 0.20 g (0.5 mmole) of macrocyclic diamine **10** was treated with 1.5 mmole (0.36 g) of **21** to give 0.22 g (56%) of viscous liquid **16**; ^{1}H nmr: δ 2.39 (s, 6H); 2.89 (m, 4H), 2.73-2.79 (m, 8H), 2.95 (t, *J* = 2.0 Hz, 4H), 3.06 (s, 4H), 3.59-3.67 (m, 16H), 4.1 (t, *J* = 5.0 Hz, 4H), 6.12 (d, *J* = 1.0 Hz, 2H), 6.81 (d, *J* = 2.5 Hz, 2H), 6.85-6.87 (dd, J_1 = 8.5 Hz, J_2 = 2.5 Hz, 2H), 7.48 (d, *J* = 8.5 Hz, 2H); ^{13}C nmr: δ 20.3, 31.3, 31.5, 33.4, 55.0, 55.8, 57.2, 68.7, 71.3, 72.3, 73.0, 103.2, 113.6, 114.2, 115.3, 127.7, 154.3, 156.8, 162.9, 163.3; ms (fab) for $C_{40}H_{55}N_2O_{10}S_2$, calcd. 787.3, found 787.3; hrms for $C_{40}H_{55}N_2O_{10}S_2$ $(M+H)^+$, calcd. 787.3298, found 787.3301.

1,13-Bis[3-(4-methyl-7-coumarinyl)oxypropyl]-1,13-diaza-4,7,10,19-tetraoxa-16,22-dithiacyclotetracosane (**17**).

Ligand **17** (0.22 g, 54%) was obtained as a viscous liquid from 0.20 g (0.5 mmole) of macrocyclic diamine **10** and 0.45 g (1.5 mmole) of **22**, according to the general procedure; ^{1}H nmr: δ 2.04 (s, 4H), 2.40 (s, 6H), 2.73 (t, *J* = 6.0 Hz, 4H), 2.75 (m, 4H), 2.81 (t, *J* = 2.0 Hz, 4H), 2.84 (t, *J* = 0.9 Hz, 4H), 3.40 (t, *J* = 1.5 Hz, 4H), 3.58 (t, *J* = 3.5 Hz, 4H), 3.62 (t, *J* = 6.0 Hz, 4H), 3.65 (t, *J* =

6.5 Hz, 4H), 3.68 (t, *J* = 6.0 Hz, 4H), 4.10 (t, *J* = 6.0 Hz, 4H), 6.12 (d, *J* = 1.0 Hz, 2H), 6.80 (d, *J* = 2.5 Hz, 2H), 6.85 (dd, J_1 = 8.5 Hz, J_2 = 2.5 Hz, 2H), 7.48 (d, *J* = 9.0 Hz, 2H); ^{13}C nmr: δ 18.6, 26.5, 30.0, 31.9, 46.7, 51.2, 53.2, 54.7, 66.2, 70.5, 71.3, 101.5, 109.0, 112.5, 113.6, 125.5, 152.5, 155.2, 161.2, 161.9; ms (fab) for $C_{42}H_{59}N_2O_{10}S_2$ $(M+H)^+$, calcd. 815.4; 815.4; hrms for $C_{42}H_{58}N_2O_{10}S_2$ (M^+), calcd. 814.3533, found: 814.3530

1-[3-(4-methyl-7-coumarinyl)oxypropyl]-1,13-diaza-4,7,10,19-tetraoxa-16,22-dithiacyclotetracosane (**18**).

One-arm product **18** was isolated as a viscous liquid when ligand **17** was prepared according to the general procedure; ^{1}H nmr: δ 1.94-1.98 (m, 2H), 2.40 (s, 3H), 2.72-2.77 (m, 10H), 2.89 (t, *J* = 6.0 Hz, 2H), 2.95 (t, *J* = 9.0 Hz, 2H), 3.46-3.73 (m, 20H), 4.11 (t, *J* = 6.0 Hz, 2H), 6.12 (s, 1H), 6.83 (d, J = 2.0 Hz, 1H), 6.88 (t, *J* = 8.5 Hz, 1H), 7.49 (d, *J* = 8.5 Hz, 1H); ^{13}C nmr: δ 18.6, 26.6, 29.6, 30.0, 32.0, 32.2, 47.7, 47.8, 51.1, 53.5, 54.8, 62.5, 66.5, 68.9, 70.1, 70.2, 70.6, 70.9, 71.2, 71.8, 101.5, 111.8, 112.5, 113.5, 125.5, 152.5, 155.2, 161.2, 162.0; hrms (fab) for $C_{29}H_{47}N_2O_7S_2$ $(M+H)^+$, calcd. 599.2824, found, 599.2819.

1,13-Bis-(3-comarinylaminoformylmethyl)-1,13-diaza-4,7,10,19-tetraoxa-16,22-dithiacyclotetracosane(**19**).

According to the general procedure, 0.20 g (0.5 mmole) of diamine **10** reacted with 1.5 mmole (0.36 g) of **23** to give 0.20 g (51%) of viscous liquid ligand **19**; ^{1}H nmr: δ 2.77-2.92 (m, 16H), 3.42 (m, 4H), 3.67-3.79 (m, 16H), 7.25-7.29 (m, 4H), 7.37 (d, *J* = 1.4 Hz, 2H), 7.42 (dd, J_1 = 8.6 Hz, J_2 = 1.4 Hz, 2H), 8.68 (d, *J* = 5.4 Hz, 2H), 10.03 (s, 2H); ^{13}C nmr: δ 29.6, 29.9, 31.6, 54.5, 55.7, 59.6, 69.5, 70.5, 71.4, 116.2, 119.8, 123.3, 123.9, 124.9, 127.6, 129.4, 150.1, 158.1, 171.2; ms (fab) for $C_{38}H_{49}N_4O_{10}S_2$ $(M+H)^+$, calcd. 785.3, found 785.3; hrms for $C_{38}H_{49}N_4O_{10}S_2$ $(M+H)^+$, calcd. 785.2890, found, 785.2896.

Anal. Calcd. for $C_{38}H_{48}N_4O_{10}S_2$: C, 58.15; H, 6.16. Found C, 57.82; H, 5.87.

1,13-Bis-(1-naphthylaminoformylmethyl)-1,13-diaza-4,7,10,19-tetraoxa-16,22-dithiacyclotetracosane(**20**).

Ligand **20** (0.20 g, 53%) was obtained as viscous liquid from 0.20 g (0.5 mmole) of macrocyclic diamine **10** and 0.33 g (1.5 mmole) of **24** according to the general procedure; ^{1}H nmr: δ 2.69 (t, *J* = 5.0 Hz, 4H), 2.85 (s, 4H), 2.90 (s, 4H), 2.98 (s, 4H), 3.27 (s, 4H), 3.41 (m, 4H), 3.44 (m, 4H), 3.53 (t, *J* = 4.5 Hz, 4H), 3.59 (t, *J* = 2.5 Hz, 4H), 7.44-7.52 (m, 6H), 7.65(d, *J* = 8.5 Hz, 2H), 7.82-7.84 (dd, J_1 = 8.5 Hz, J_2 = 1.5 Hz, 2H), 8.08 (t, *J* = 8.0 Hz, 4H), 10.11 (s, 2H); ^{13}C nmr: δ 32.4, 33.5, 56.5, 56.7, 61.1, 70.3, 71.9, 72.0, 72.9, 121.3, 123.3, 127.0, 127.5, 127.6, 127.7, 128.7, 130.2, 134.4, 135.8, 172.5; ms (fab) for $C_{40}H_{53}N_4O_6S_2$ $(M+H)^+$, calcd. 749.3, found, 749.3; hrms for $C_{40}H_{53}N_4O_6S_2$ $(M+H)^+$, calcd. 749.3406, found 749.3401.

Anal. Calcd. for $C_{40}H_{52}N_4O_6S_2$: C, 64.14; H, 7.00. Found C, 64.42; H, 6.87.

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