method. On removal of the ether a light yellow crystalline residue, a melting point of 141 °C was obtained. Recrystallization from methanol gave needles: mp 146–147 °C;[11b] yield 0.4 g (77.5%); IR (KBr) 1700 cm^{-1} (C=O, ester); ^1H NMR ($CDCl_3$) δ 3.9 (s, 6 H), 7.66 (s, 2 H).

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Registry No. 1, 3141-27-3; 3, 18246-28-1; 4, 38611-18-6; 5, 93041-05-5; 6, 93041-06-6; 7, 93041-07-7; 8, 17906-71-7; LDA, 120-40-1; THF, 109-99-9; *n*-BuLi, 109-72-8; HCl, 7647-01-0; *n*-hexane, 110-54-3; trimethylsilyl chloride, 75-77-4; 2,5-bis(trimethylstannyl)thiophene, 86134-26-1; trimethyltin chloride, 1066-45-1; tri-*n*-butyltin chloride, 1461-22-9; 2,5-dibromo-3-(phenylselenyl)thiophene, 93041-08-8; phenylselenyl chloride, 5707-04-0; thiophene-2,5-dicarboxylic acid, 4282-31-9; dry ice, 124-38-9; dimethyl thiophene-2,5-dicarboxylate, 4282-34-2; diazomethane, 334-88-3.

Synthesis of Unsymmetrical 1,4-Bis[(aminoalkyl)amino]anthracene-9,10-diones for Antineoplastic Evaluation

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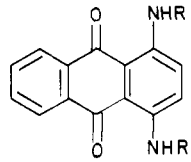
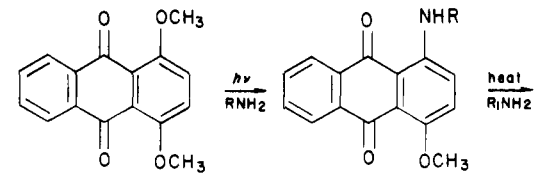
Recently the synthesis and antineoplastic evaluation of a number of symmetrically substituted 1,4-bis[(aminoalkyl)amino]anthracene-9,10-diones such as **1a** have been reported.[1] Compound **1b** and its 5,8-dihydroxy-substituted congener have shown outstanding antineoplastic activity.



1a, R = R_1 = $(CH_2)_2NH_2$
1b, R = R_1 = $(CH_2)_2NH(CH_2)_2OH$

As part of a drug development program, we report a convenient two-step synthetic sequence commencing with 1,4-dimethoxyanthracene-9,10-dione (**2**) which lends itself to the synthesis of symmetrically and unsymmetrically substituted analogues related to **1**. This two-step photolytic–thermolytic procedure is outlined in Scheme I and allows a facile preparation of unsymmetrical analogues of **1** to further define the structure–activity relationship of this new class of antitumor agents.

Scheme I



2 **3**

Table I. Photolytic Substitutions of 2 Leading to 3

3	R	% yield
a	$CH_2CH=CH_2$	44
b	$(CH_2)_3CH_3$	51
c	$(CH_2)_2NH_2$	26
d	$(CH_2)_3NH_2$	28
e	$(CH_2)_2NHCOCH_3$	31
f	$(CH_2)_3NHCOCH_3$	35
g	$(CH_2)_4NHCOCH_3$	30
h	$(CH_2)_5NHCOCH_3$	39
i	$(CH_2)_2N(CH_3)_2$	2

Table II. Thermal Substitutions of 3 Leading to 1

1	R	R^1	% yield
c	$CH_2CH=CH_2$	$CH_2CH=CH_2$	28
d	$(CH_2)_3CH_3$	$CH_2C_6H_5$	64
e	$(CH_2)_3CH_3$	$(CH_2)_2N(CH_3)_2$	58
f	$(CH_2)_2NHCOCH_3$	$(CH_2)_2N(CH_3)_2$	72
g	$((CH_2)_3NH_2$	$(CH_2)_2N(CH_3)_2$	55
h	$(CH_2)_3NHCOCH_3$	$(CH_2)_2N(CH_3)_2$	70
i	$(CH_2)_4NHCOCH_3$	$(CH_2)_2N(CH_3)_2$	79
j	$(CH_2)_5NHCOCH_3$	$(CH_2)_2N(CH_3)_2$	92

Several experimental procedures have been utilized for the preparations of symmetrical substituted analogues of **1**. Treatment of quinizarin (1,4-dihydroxyanthracene-9,10-dione) or leucoquinizarin (followed by a subsequent oxidation step) with various diamines has found general applicability.[1,2] In certain cases such as **1a** or **1b**, competitive cyclizations can occur to form quinoxalines.[1d,3] Other methods which have led to symmetrical derivatives are the treatment of 1,4-dichloroanthracene-9,10-dione with allkylamines[4] and heating borate esters of quinizarin with arylamines.[5]

This research is patterned after the observation of Griffiths and Hawkins[6] who found that 1-methoxyanthracene-9,10-dione on photolysis in the presence of primary alkylamines afforded the corresponding 1-(alkylamino)anthracene-9,10-diones. It is generally observed in aromatic nucleophilic photochemical substitutions that the position meta to an electron-withdrawing group is activated relative to the ortho or para positions. This is in direct contrast to thermal displacments in which electron-withdrawing groups must be ortho or para to the leaving group.

Irradiation of a methylene chloride solution of **2** in the presence of allylamine, 1-aminobutane, and several α,ω-diamines lead to the monosubstituted products **3** in 30–51% yields (Table I). In the examples where α,ω-diamines were used, purification of the free amine was

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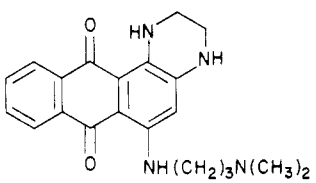
difficult. However, treatment with acetic anhydride led to the readily isolable and easily purified acetamide derivatives.

Only small amounts of the bis substitution products could be detected by TLC analysis of the crude reaction mixtures. It is of interest to note that irradiation of a methylene chloride solution of 2-(dimethylamino)ethylamine led to a poor yield of **3i** (less that 2%). This is an obvious limitation for the preparation of N-substituted analogues.

The thermolytic substitution of the methoxy group could readily be accomplished by refluxing **3** in the appropriate amine for 3–5 h to yield **1** in 28–92% yields (Table II).

Attempted thermal substitution of **3c** with 3-(dimethylamino)propylamine led to the quinoxaline **4** (45%).[1d,3] This undersirable cyclization can be cirumvented by use of the amide.



4

The antineoplastic evaluations of the compounds synthesized are currently under way and the results will be reported elsewhere.

Experimental Section

Melting points were determined on a Thomas-Hoover melting point apparatus and are uncorrected. ^{1}H NMR were run on a Bruker WM-250 pulsed Fourier transform NMR spectrometer. TLC precoated silica gel plates (Eastman Chromagram sheet with fluorescent indicator) were used to monitor reactions. Baker analyzed 80–200-mesh silica gel was utilized for column chromatography. Microanalyses were performed by Robertson Laboratories, Florham Park, NJ. Mass spectra were run on a Finnigan MAT 4610 mass spectrometer. Irradiations were performed through Pyrex by using a General Electric or Sylvania 275-W standard tanning sunlamp.

1,4-Dimethoxyanthracene-9,10-dione (2). A mixture of quinizarin (4.0 g, 16.7 mmol), K_2CO_3 (15.2 g, 110 mmol), and dimethyl sulfate (4.7 mL, 50 mmol) was refluxed in methyl ethyl ketone (190 mL) with stirring for 18 h. The warm reaction mixture was filtered and the solid was washed with warm methyl ethyl ketone. The filtrate was distilled until approximately 50 mL of solvent remained and was cooled and allowed to stand overnight. The yellow crystals were collected by filtration and dried to afford **2** (3.3 g, 74%). Recrystallization from methanol gave yellow needles: mp 170–171 °C (lit.[9] mp 170–171 °C); ^{1}H NMR ($CDCl_3$) δ 8.13–8.19 (m, 2 H), 7.69–7.73 (m, 2 H), 7.35 (s, 2 H), 4.00 (s, 6 H).

A. General Procedure. Photochemical Substitutions. The photochemical substitutions were performed by irradiating 0.1–0.2% (w/v) solutions of **2** in methylene chloride containing 5 equiv of the corresponding primary amine for 6 to 7 h. The reaction progress was followed by periodic TLC analysis. On removal of the solvent, the products were isolated by column chromatography on silica gel. The acetamides were prepared by treatment of the crude reaction products with acetic anhydride on the column.

1-(Allylamino)-4-methoxyanthracene-9,10-dione (3a). Following procedure A (1% solution of **2** with 14 equiv of amine, 20-h irradiation), the crude product was chromatographed by using methylene chloride as eluant and crystallized from methanol to yield purple needles: mp 146–148 °C; ^{1}H NMR ($CDCl_3$) δ 10.05 (br t, 1 H), 8.20–8.29 (m, 2 H), 7.69–7.76 (m, 2 H), 7.38 (d, 1 H), 7.11 (d, 1 H), 5.83–6.08 (m,1 H), 6.22–6.38 (m, 2 H), 3.95–4.06 (m, 5 H); mass spectrum, *m/e* (relative intensity) 294 (25.6), 293 (M^+, 100), 278 (31.1), 221 (22.4), 56 (27.4). Anal. Calcd for $C_{18}H_{15}NO_3$: C, 73.70; H, 5.15; N, 4.78. Found: C, 73.49; H, 5.21; N, 4.52.

1-(Butylamino)-4-methoxyanthracene-9,10-dione (3b). Upon irradiation for 20 h following procedure A, chromatography using methylene chloride as eluant led to a product which was crystallized from a mixture of petroleum ether and $CHCl_3$ to afford purple needles: mp 98–100 °C; ^{1}H NMR ($CDCl_3$) δ 9.93 (br t, 1H), 8.20–8.25 (m, 2 H), 7.65–7.74 (m, 2 H), 7.36 (d, 1 H), 7.13 (d, 1 H), 3.98 (s, 3 H), 3.30–3.37 (m, 2 H), 1.70–1.82 (m, 2 H), 1.45–1.57 (m, 2 H), 1.00 (t, 3 H); mass spectrum *m/e* (relative intensity) 309 (56.8, M^+), 266 (100), 237 (19.5), 209 (15.6), 152 (10.4), 139 (15.8). Anal. Calcd for $C_{19}H_{19}NO_3$: C, 73.77; H, 6.19; N, 4.53. Found: C, 73.56; H, 5.92; N, 4.32.

1-[(2-Aminoethyl)amino]-4-methoxyanthracene-9,10-dione (3c). The crude product obtained by procedure A was eluted first with ethyl acetate to remove starting material and then with methanol to afford a purple oil. The oil was extracted with warm CCl_4 and crystallized by adding petroleum ether to the CCl_4 extracts. Crystallization afforded a purple solid. Recrystallization from a mixture of CCl_4 and petroleum ether gave purple needles: mp 136–138 °C; ^{1}H NMR ($CDCl_3$) δ 10.08 (br t, 1 H), 8.21–8.27 (m, 2 H), 7.68 –7.75 (m, 2 H), 7.37 (d, 1 H), 7.17 (d, 1 H), 3.99 (s, 3 H), 3.40–3.48 (m, 2 H), 3.09 (t, 2 H), 1.75 (br s, 2 H); mass spectrum *m/e* (relative intensity) 296 (M^+, 11.3), 266 (62.3), 85 (53.2), 84 (51. 5), 71 (67.9), 57 (100). Anal. Calcd for $C_{17}H_{16}N_2O_3$: C, 68.91; H, 5.44; N, 9.45. Found: C, 68.82; H, 5.42; N, 9.29.

1-[(3-Aminopropyl)amino]-4-methoxyanthracene-9,10-dione (3d). The crude product obtained from procedure A was triturated with warm petroleum ether to remove excess amine. Chromatography (silica gel, CCl_4:CH_2Cl_2, 1:1) was performed by slowly increasing the polarity of the solvent to CH_2Cl_2 to remove the unreacted 1,4-dimethoxyanthraquinone. Upon elution with methanol, a purple band slowly developed. A purple oil remained upon removal of the solvent. The oil was extracted with warm CCl_4 and crystallized by adding petroleum ether to the combined CCl_4 extracts. Recrystallization from a mixture of CCl_4 and petroleum ether afforded an analytical sample: mp 108–110 °C; ^{1}H NMR ($CDCl_3$) δ 9.95 (br t, 1 H), 8.21–8.25 (m, 2 H), 7.68–7.73 (m, 2 H), 7.37 (d, 1 H), 7.17 (d, 1 H), 4.00 (s, 3 H), 3.39–3.48 (m, 2 H), 2.94 (t, 2 H), 1.86–1.98 (m, 2 H), 1.36 (br s, 2 H). Anal. Calcd for $C_{18}H_{18}N_2O_3$: C, 69.66; H, 5.85; N, 9.03. Found: C, 69.75; H, 5.95; N, 8.95.

1-[(2-Acetamidoethyl)amino]-4-methoxyanthracene-9,10-dione (3e). Column chromatography of the product from procedure A (elution with CH_2Cl_2) followed by $CHCl_3$ removed unreacted starting material. Acetic anhydride (30 mL) was added to the column, and on eluting with $CHCl_3$ a purple band developed. This fraction was collected and concentrated on a rotary evaporator, triturated with water and petroleum ether, and dried in vacuo to afford a purple solid. Recrystallization from xylene afforded purple needles: mp 207–209 °C; ^{1}H NMR ($CDCl_3$) δ 9.93 (br t, 1 H), 8.10–8.22 (m, 2 H), 7.65–7.72 (m, 2 H), 7.30 (d, 1 H), 7.20 (d, 1 H), 6.18 (br t, 1 H), 3.98 (s, 3 H), 3.47–3.61 (m, 4 H), 2.08 (s, 3 H). Anal. Calcd for $C_{19}H_{18}N_2O_4$: C, 67.44; H, 5.36; N, 8.28. Found: C, 67.42; H, 5.48; N, 8.08.

1-[(3-Acetamidopropyl)amino]-4-methoxyanthracene-9,10-dione (3f). The residue from procedure A was dissolved in 100 mL of CH_2Cl_2 and absorbed onto silica gel. This was introduced to a column of silica gel and CH_2Cl_2. The starting material was eluted with CH_2Cl_2 and 30 mL of acetic anhydride was then added to the column. The amide was eluted with $CHCl_3$ and recrystallized from xylene to afford purple needles: mp 153–155 °C; ^{1}H NMR ($CDCl_3$) δ 9.89 (br t, 1 H), 8.17–8.23 (m, 2 H), 7.65–7.73 (m, 2 H), 7.26 (d, 1 H), 7.02 (d, 1 H), 6.12 (br t, 1 H), 3.98 (s, 3 H), 3.43–3.55 (m, 2 H), 3.31–3.40 (m, 2 H), 2.08 (s, 3 H), 1.92–2.08 (m, 2 H). Anal. Calcd for $C_{20}H_{20}N_2O_4$: C, 68.17; H, 5.72; N, 7.95. Found: C, 68.35; H, 5.69; N, 7.88.

1-[(4-Acetamidobutyl)amino]-4-methoxyanthracene-9,10-dione (3g). The residue from procedure A was dissolved in methanol (15 mL), and the methanol solution was poured into saturated NaCl (100 mL). On standing overnight, the solid was collected by filtration and then dried. The solid was extracted

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with warm $CHCl_3$ (3 × 35 mL) and silica gel was added to the combined $CHCl_3$ extracts. The solvents were removed and the silica gel was added to a column, and acetylation and chromatography was performed as in **3e** above. A purple solid was obtained: mp 151–153 °C; ^1H NMR ($CDCl_3$) δ 9.91 (br t, 1 H) 8.18–8.24 (m, 2 H), 7.66–7.73 (m, 2 H), 7.37 (d, 1 H), 7.11 (d, 1 H), 5.67 (br t, 1 H), 3.99 (s, 3 H), 3.30–3.42 (m, 4 H), 2.01 (s, 3 H), 1.64–1.86 (m, 4 H). Anal. Calcd for $C_{21}H_{22}N_2O_4$: C, 68.84, H, 6.05, N, 7.65. Found: C, 68.57, H, 6.34, N, 7.52.

1-[(5-Acetamidopentyl)amino]-4-methoxyanthracene-9,10-dione (3h). The residue from procedure A (48-h irradiation) was chromatographed. The unreacted starting material was eluted with 2% methanol in $CHCl_3$. Acetic anhydride (30 mL) was then introduced to the column and the amide was eluted with 4% methanol in $CHCl_3$. Recrystallization from xylene yielded purple needles melting at 145–147 °C: ^1H NMR ($CDCl_3$) δ 9.88 (br t, 1 H), 8.21 (m, 2 H), 7.69 (m, 2 H), 7.19 (dd, 2 H), 6.01 (br t, 1 H), 3.97 (s, 3 H), 3.29 (m, 4 H), 2.0 (s, 3 H), 1.76 (m, 2 H), 1.56 (m, 4H); mass spectrum, *m/e* 380.2 (M^+, 100). Anal. Calcd for $C_{22}H_{24}N_2O_4$: C, 69.46; H, 6.36; N, 7.36. Found: C, 69.76; H, 6.57; N, 7.11.

B. Thermal Substitution. General Procedure. The substitution of the methoxy group was carried out by refluxing a 10% solution of the monosubstituted compound in the corresponding amine for 3–5 h. The reaction progress was followed by TLC. The reaction mixture was poured into either ice–water or brine and the crude product filtered. Chromatography (silica gel) was performed when necessary.

1,4-Bis(allylamino)anthracene-9,10-dione (1c). The crude product from procedure B (reflux, 40 h) was chromatographed with CH_2Cl_2 as eluant to afford a blue solid which was recrystallyzed from petroleum ether (high boiling) to give blue needles: mp 140–141 °C; ^1H NMR ($CDCl_3$) δ 10.83 (br t, 2 H), 8.31–8.39 (m, 2 H), 7.67–7.74 (m, 2 H), 7.16 (s, 2 H), 5.92–6.08 (m, 2 H), 5.20–5.37 (m, 4 H), 4.02–4.08 (m, 4 H); mass spectrum, *m/e* (relative intensity) 319 (18.0), 318 (M^+, 100), 277 (29.2), 56 (11.4). Anal. Calcd for $C_{20}H_{18}N_2O_2$: C, 75.45; H, 5.70; N, 8.80. Found: C, 75.24; H, 5.82; N, 8.69.

1-(Benzylamino)-4-(butylamino)anthracene-9,10-dione (1d). The crude solid from procedure B was chromatographed (silica gel, CH_2Cl_2) to give a blue crystalline solid. Recrystallization from high-boiling petroleum ether afforded blue needles: mp 162–163 °C; ^1H NMR ($CDCl_3$) δ 11.14 (br t, 1 H), 10.76 (br t, 1 H), 8.33–8.37 (m, 2 H), 7.68–7.72 (m, 2 H) 7.15–7.37 (m, 7 H), 4.65 (d, 2 H), 3.32–3.40 (m, 2 H), 1.63–1.76 (m, 2 H), 1.46–1.58 (m, 2 H), 0.98 (t, 3 H); mass spectrum, *m/e* (relative intensity) 384 (100, M^+), 341 (58.0), 293 (50.4), 91 (67.0). Anal. Calcd for $C_{25}H_{24}N_2O_2$: C, 78.10; H, 6.29; N, 7.29. Found: C, 77.95; H, 5.98; N, 7.03.

1-[[2-(Dimethylamino)ethyl]amino]-4-(butylamino)-anthracene-9,10-dione (1e). Column chromatography of the crude product from procedure B (silica gel, acetone) gave a small amount of starting material as the first fraction. Upon elution with a mixture of acetone and methanol (1:3), a dark blue band developed. After removal of the solvent, blue crystalline solid remained which was recrystallized from petroleum ether to yield blue needles: mp 149–150 °C; ^1H NMR ($CDCl_3$) δ 10.79 (br t, 2 H), 8.32–8.38 (m, 2 H), 7.66–7.72 (m, 2 H), 7.25 (s, 2 H), 3.47–3.55 (m, 2 H), 3.37–3.45 (m, 2 H), 2.67 (t, 2 H), 2.35 (s, 6 H), 1.67–1.82 (m, 2 H), 1.52 (m, 2 H), 1.00 (t, 3 H); mass spectrum, *m/e* (relative intensity) 365 (M^+, 4.3), 307 (2.3), 58 (100). Anal. Calcd for $C_{22}H_{27}N_3O_2$: C, 72.30; H, 7.45; N, 11.50. Found: C, 72.29; H, 7.29; N, 11.31.

1-[(2-Acetamidoethyl)amino]-4-[[2-(dimethylamino)-ethyl]amino]anthracene-9,10-dione (1f). Chromatography of the crude product from procedure B over silica gel using CH_2Cl_2 as eluant and then changing the solvent polarity from CH_2Cl_2 to $CHCl_3$ removed starting material. Upon elution with $CHCl_3$:CH_3OH, 10:1, a blue solid was collected. Recrystallization from xylene afforded an analytical sample: mp 192–194 °C; ^1H NMR ($CDCl_3$) δ 10.72–10.82 (m, 2 H), 8.23–8.25 (m, 2 H), 7.64–7.73 (m, 2 H), 7.22 (d, 1 H), 7.12 (d, 1 H), 6.28 (br t, 1 H), 3.42–3.60 (m, 6 H), 2.68 (t, 2 H), 2.38 (s, 6 H), 2.08 (s, 3 H). Anal. Calcd for $C_{22}H_{26}N_4O_3$: C, 66.99; H, 6.64; N, 14.20. Found: C, 67.01; H, 6.85; N, 13.88.

1-[(3-Aminopropyl)amino]-4-[[2-(dimethylamino)ethyl]-amino]anthracene-9,10-dione (1g). The solid from procedure B was dried in vacuo and extracted with $CHCl_3$. The chloroform was removed under reduced pressure to afford a blue solid which was recrystallized from a mixture of CCl_4 and petroleum ether to give a blue crystalline solid. A second recrystallization from a mixture of petroleum ether and xylene afforded an analytical sample: mp 111–113 °C; ^1H NMR ($CDCl_3$) δ 10.77 (br t, 2 H), 8.31–8.38 (m, 2 H), 7.66–7.72 (m, 2 H), 7.27 (s, 2 H), 3.47–3.54 (m, 4 H), 2.93 (t, 2 H), 2.68 (t, 2 H), 2.35 (s, 6 H), 1.88–1.97 (m, 2 H), 1.42 (br s, 2 H); mass spectrum, *m/e* (relative intensity) 366 (M^+, 3.3), 321 (5.2), 84 (10.8), 58 (100). Analyzed as amide **1h**.

1-[(3-Acetamidopropyl)amino]-4-[[2-(dimethylamino)-ethyl]amino]anthracene-9,10-dione (1h). The solid obtained from procedure B was dissolved in $CHCl_3$ and silica gel was added to the solution. The solvent was removed and the silica gel was added to a column. Starting material was eluted with $CHCl_3$ and the product with CH_3OH. The solvent was removed to give a blue solid. An analytical sample was prepared by recrystallization: mp 193–194 °C; ^1H NMR ($CDCl_3$) δ 10.65–10.78 (m, 2 H), 8.24–8.36 (m, 2 H), 7.62–7.72 (m, 2 H), 7.10–7.20 (m, 2 H), 6.03 (br t, 1 H), 3.39–3.52 (m, 6 H), 2.68 (t, 2 H), 2.36 (s, 6 H), 1.92–2.05 (m, 5 H). Anal. Calcd for $C_{23}H_{28}N_4O_3$: C, 67.62; H, 6.91; N, 13.72. Found: C, 67.49; H, 6.70; N, 13.73.

1-[(4-Acetamidobutyl)amino]-4-[[2-(dimethylamino)-ethyl]amino]anthracene-9,10-dione (1i). The solid from procedure B was chromatographed on silica gel. Starting material was eluted with CH_2Cl_2 and the product was eluted with 10% CH_3OH in $CHCl_3$ to give a blue solid which was recrystallized from xylene and then toluene to give a blue solid: mp 160–162 °C; ^1H NMR ($CDCl_3$) δ 10.73–10.82 (m, 2 H), 8.28–8.40 (m, 2 H), 7.65–7.72 (m, 2 H), 7.13 (m, 2 H), 5.73 (br t, 1 H), 3.28–3.55 (m, 6 H), 2.68 (t, 2 H), 2.37 (s, 6 H), 2.01 (s, 3 H), 1.67–1.84 (m, 4 H). Anal. Calcd for $C_{24}H_{30}N_4O_3$: C, 68.22; H, 7.16; N, 13.26. Found: C, 68.13; H, 7.12; N, 13.03.

1-[(5-Acetamidopentyl)amino]-4-[[2-(dimethylamino)-ethyl]amino]anthracene-9,10-dione (1j). Chromatography of the crude product from procedure B over silica gel, eluting with $CHCl_3$, 2% CH_3OH in $CHCl_3$, then 5% and finally 10% CH_3OH in $CHCl_3$ led to **1j**. Recrystallization from toluene gave pure needles: mp 138–139 °C.; ^1H NMR ($CDCl_3$) δ 10.80 (br t, 2 H), 8.35 (m, 2 H), 7.69 (m, 2 H), 7.27 (s, 2 H), 5.63 (s, 1 H), 3.53 (dt, 2 H), 3.43 (dt, 2 H), 3.30 (dt, 2 H), 2.68 (t, 2 H), 2.37 (s, 6 H), 1.97 (S, 3 H), 1.80 (m, 2 H), 1.58 (m, 4 H); mass spectrum, *m/e* (relative intensity) 437 (100). Anal. Calcd for $C_{25}H_{32}N_4O_3$; C, 68.78; H, 7.39; N, 12.83. Found: C, 68.83; H, 7.62; N, 12.77.

Quinoxaline (4). A solution of **3c** (0.200 g, 0.67 mmol) and 3-(dimethylamino)propylamine (10 mL) was heated with stirring for 18 h at 80 °C. The excess amine was distilled off under reduced pressure and the crude oil was dried in vacuo. The oil was triturated with warm petroleum ether (high boiling), and the remaining oil was chromatographed (alumina, CCl_4/CH_2Cl_2; 1/1). To remove the residual amine, the polarity of the solvent was slowly increased, elluting initially with CCl_4 and CH_2Cl_2 (1:1), then CH_2Cl_2, followed by ethyl acetate, and finally with ethyl acetate and methanol (3:1). The major blue zone was collected in three fractions, one crystalline, the other two oily, to give a combined yield (0.110 g, 45%). Recyrstallization of each fraction afforded blue needles: mp 176–178 °C; ^1H NMR ($CDCl_3$) δ 11.22 (br t, 1 H), 11.01 (br t, 1 H), 8.30–8.38 (m, 2 H), 7.59–7.72 (m, 2 H), 6.19 (s, 1 H), 4.89 (br s, 1 H), 3.63–3.69 (m, 2 H), 3.53–3.59 (m, 2 H), 3.34–3.42 (m, 2 H), 2.49 (t, 2 HO), 2.30 (s, 6 H), 1.91–2.01 (m, 2 H); mass spectrum, *m/e* (relative intensity) 364 (M^+, 2.8), 3.06 (10.7), 58 (100). Anal. Calcd for $C_{21}H_{24}N_4O_2 \cdot {}^1/_2H_2O$: C, 67.53; H, 6.74; N, 15.00. Found: C 67.90; H, 6.67; N, 14.72.

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Registry No. **1c**, 93184-42-0; **1d**, 93184-43-1; **1e**, 93184-44-2; **1f**, 93184-45-3; **1g**, 93184-46-4; **1h**, 93184-47-5; **1i**, 93184-48-6; **1j**, 93184-49-7; **2**, 6119-74-0; **3a**, 93184-50-0; **3b**, 82874-66-6; **3c**, 93184-51-1; **3d**, 93184-52-2; **3e**, 93184-53-3; **3f**, 93184-54-4; **3g**, 93184-55-5; **3h**, 93184-56-6; **3i**, 93184-57-7; **4**, 93253-84-0; $NH_2CH_2CH{=}CH_2$, 107-11-9; $BuNH_2$, 109-73-9; $NH_2(CH_2)_2NH_2$, 107-15-3; $NH_2(CH_2)_3NH_2$, 109-76-2; $NH_2(CH_2)_4NH_2$, 110-60-1; $NH_2(CH_2)_5NH_2$, 462-94-2; $NH_2(CH_2)_2NMe_2$, 108-00-9; $NH_2(CH_2)_3NMe_2$, 109-55-7; NH_2CH_2Ph, 100-46-9; quinizarin, 81-64-1.