Molecular Architecture. 2.[1] Synthesis and Metal Complexation of Heptacyclic Terpyridyl Molecular Clefts

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Methods are described for the synthesis of a series of functionalized derivatives of 9-butyl-1,2,3,4,5,6,7,8-octahydroacridine (**9**), a building block for several types of highly preorganized host compounds. A key intermediate is 5-benzylidene-9-butyl-2,3,5,6,7,8-hexahydroacridin-4(1*H*)-one (**23**), which can also be used in the syntheses of torands and hydrogen-bonding hexagonal lattice receptors. A tridentate cleft (**20**), consisting of 2,2′;6′,2″-terpyridine imbedded in a heptacyclic framework, and a corresponding pentadentate diketone (**6**) were synthesized from **9** in five and seven steps, respectively. The picrate extraction method was used to estimate the solution stabilities of alkali metal complexes of heptacyclic terpyridyls **6** and **20**, which was also compared with a flexible terpyridyl (**37**). Alkali metal complexes of both heptacyclic terpyridyls showed relatively high K_s values, but low size selectivity. Pentadentate host **6** binds Na^+ and K^+ more strongly than do most hexadentate crown ethers; flexible tridentate analogue **37** failed to extract alkali metal picrates into chloroform. The complexation abilities of **6** and **20** are attributed to enforced orientation of functional group dipoles toward the center of the molecular cleft. Sodium and potassium picrate complexes of pentadentate cleft **6** were synthesized (1:1 stoichiometry), and a 2:1 complex of calcium triflate ($\mathbf{6}_2{\cdot}Ca(CF_3SO_3)_2$) was also prepared.

The discovery of alkali metal complexation by crown ethers[2] foreshadowed development of several other host families,[3] including podands, cryptands,[4] lariat ethers,[5] spherands,[6] cryptahemispherands,[6c] and torands.[7] The examples shown in Figure 1 illustrate the general trend toward ion encapsulation and ligand rigidity for cryptands, spherands and cryptaspherands, compared with crown ethers. These structural modifications generally produce higher selectivity and stronger binding of alkali metals at the expense of rapid equilibration. Fast kinetics needed for many analytical and preparative applications of metal ligands can be achieved by decreasing the number of macrocyclic rings. For example, podands and lariat ethers may be considered open-chain analogues of crown ethers and cryptands, respectively. This modification enhances exchange rates but reduces the selectivities of the hosts and stabilities of the alkali metal complexes.

Our studies have explored the unique combination of rigidity and planarity in hosts for metal ions. We have previously shown that an all-sp^2 hybridized hexaaza-18-crown-6 host forms strong complexes with alkali metal salts.[1,8] We have also introduced the torands[7] (e.g., **5**), in which the macrocyclic perimeter is completely formed by smaller, fused rings. The stabilities of alkali metal complexes of torand **5** are comparable to those of cryptaspherands, yet cation exchange between host molecules is faster. Reported herein are the syntheses and some complexation properties of heptacyclic terpyridyl molecular clefts, represented by diketone **6** in Figure 1. These

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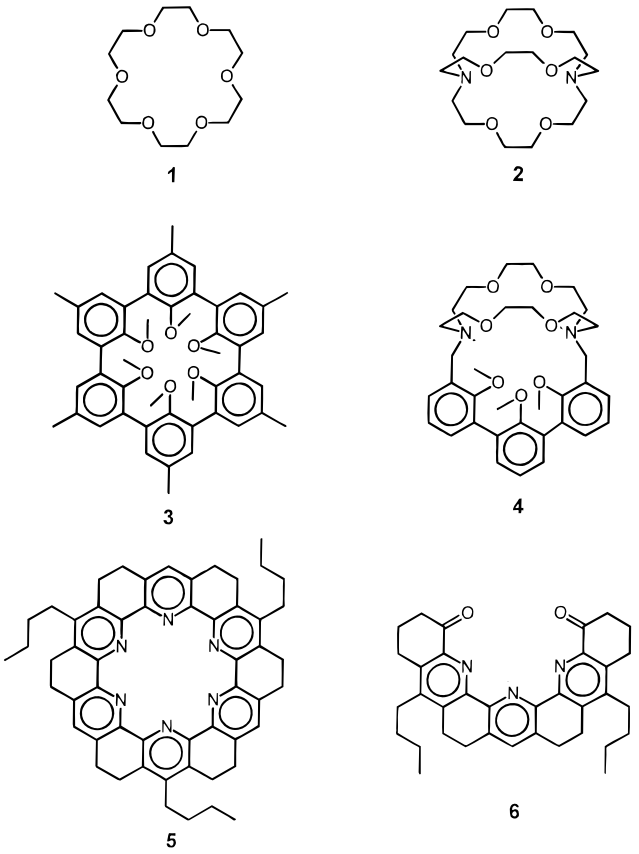


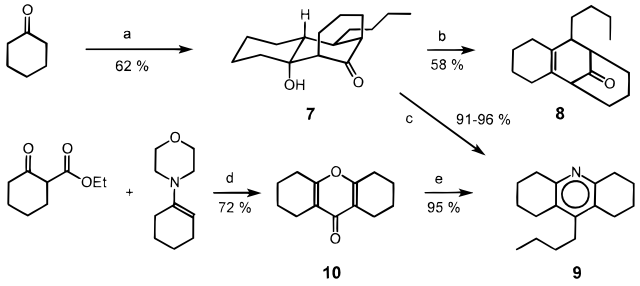
Figure 1. Representative members of several classes of host compounds: crown ether (**1**), cryptand (**2**), spherand (**3**), cryptaspherand (**4**), torand (**5**) and heptacyclic terpyridyl cleft (**6**).

preorganized podands constitute a family of host compounds that form alkali metal complexes of comparable strength to those of crown ethers. Also reported are the syntheses of key intermediates used to prepare torands[7] and hexagonal lattice hosts for hydrogen-bonded complexation of organic guests.[7d,9]

Results and Discussion

Syntheses. The 9-butyl-1,2,3,4,5,6,7,8-octahydroacridine (BuOHA) ring system was chosen as the building block for assembly of polycyclic clefts and torands because octahydroacridines can be functionalized selectively and the *n*-butyl group was expected to produce a good balance between solubility, crystallinity, and spectroscopic simplicity. Thummel et al.[10] have used unsubstituted 1,2,3,4,5,6,7,8-octahydroacridine (OHA) for synthesis of "polyaza cavity-shaped" molecules of similar structure to the hexagonal lattice clefts described here. We recognized that introduction of an alkyl group would enhance lipophilicity of the host compounds, enabling the evaluation of complexation by liquid−liquid or solid−liquid extraction. By later synthetic modification, side-chains might also be useful for immobilization or conjugation of hosts to solid supports, soluble polymers, or biomolecules.

Scheme 1[a]



[a](a) *n*-pentanal, KOH, EtOH; (b) TsOH, EtOH, heat; (c) NH_4OAc, $Cu(OAc)_2 \cdot H_2O$, HOAc; (d) xylene, heat; (e) BuLi, hexane, THF; HOAc, NH_4OAc.

Several methods were investigated for preparation of BuOHA (**9**, Scheme 1). Direct alkylation[11] of OHA or corresponding pyrylium salts[12] proved less useful than a two-step approach involving tricyclic keto alcohol **7**. This crystalline intermediate can be easily prepared in 500-g batches by condensation of pentanal with cyclohexanone.[13] The procedure is a modification of reported methods for condensation of cyclohexanone with aromatic and shorter-chain aliphatic aldehydes.[14] The configuration of keto alcohol **7** is tentatively assigned as shown in Scheme 1 by comparison with the structure of the methyl analogue, which was assigned by spectroscopic methods.[15]

Tricyclic keto alcohols related to **7** are known to undergo reverse intramolecular aldol condensation under acidic conditions, yielding 1,5-diketones.[16] Acidic pyrolysis gave only dehydration product **8**,[17] which probably corresponds in structure to the HCl-catalyzed dehydration product of the methyl analogue of **7**.[14a] Heating with base (NaOH or $NaHCO_3$) caused decomposition of **7** to cyclohexanone, 2-pentylidenecyclohexanone, and other products. Tricyclic keto alcohols may be converted directly to OHA derivatives by reaction with ammonium acetate,[16b,c] apparently by condensation of the 1,5-diketone formed in situ. Ammonium acetate in acetic acid is a general method for synthesis of pyridines from 1,5-diketones,[16c,18] but the yield of this cyclization is limited by disproportionation of the intermediate dihydropyridine.[13b,16c,18a,19] Reaction of hydroxylamine hydrochloride with 1,5-diketones[13a,18b,20] avoids the dispropor-

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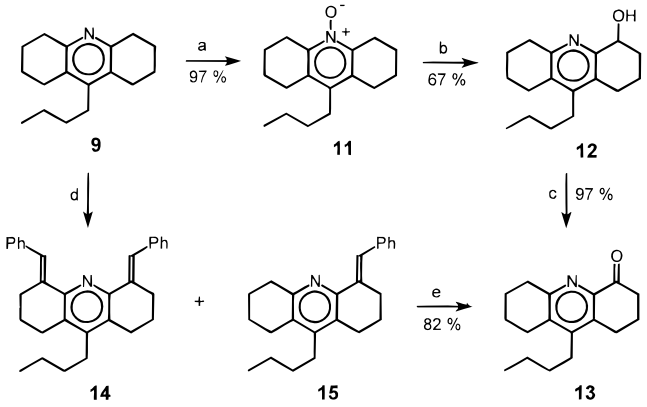
(17) The double bond position was assigned as shown in **8** according to the absence of an olefinic resonance in the ^1H NMR spectrum.

Scheme 2[a]

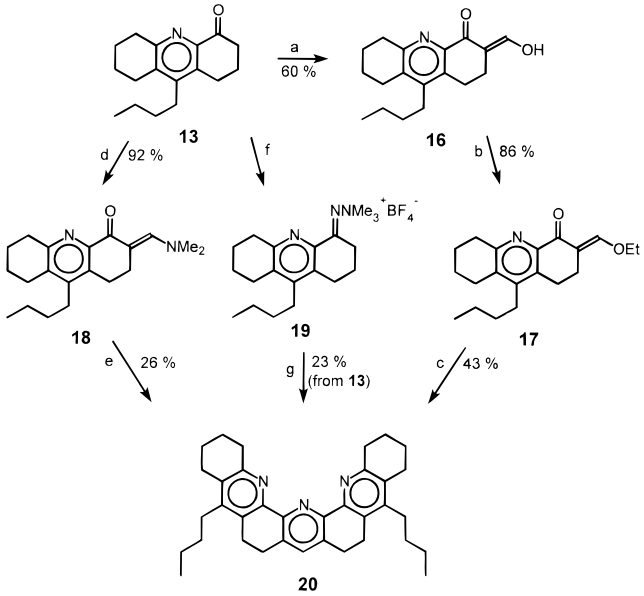


[a](a) Oxone®, $NaHCO_3$, MeOH, H_2O; (b) Ac_2O, heat; HCl, H_2O; NaOH, H_2O; (c) $Cl_2(CO)_2$, DMSO, CH_2Cl_2, Et_3N; (d) PhCHO, Ac_2O; (e) O_3, CH_2Cl_2, CH_3OH; Me_2S.

tionation of dihydropyridines, but colored byproducts are formed and both methods produce **9** from **7** in comparable yield.[13,19] The method of choice for preparation of BuOHA (**9**) is reaction of **7** with NH_4OAc and $Cu(OAc)_2$ in acetic acid.[13b,19] Cu^{2+} apparently oxidizes the intermediate dihydropyridine before disproportionation occurs. With modification of the workup method[13b] this reaction gives a 95% yield of **9** on a 200-g scale. An alternative two-step synthesis of BuOHA (**9**) via 1,2,3,4,5,6,7,8-octahydroxanthen-9-one (**10**)[21] was also investigated. An improved preparation[21b] of **10** was employed (cf. Scheme 1). Reaction of **10** with butyllithium followed by NH_4OAc in acetic acid gave **9** in 95% yield. This method produces **9** in comparable overall yield from commercially available starting materials and may be useful for introducing other substituents.

Coupling of two OHA subunits to form heptacyclic terpyridyls, such as **6**, requires oxidation of the methylene group adjacent to the pyridine N atom (position 4). This was accomplished via *N*-oxide **11** (Scheme 2), which can be prepared by reaction of **9** with MCPBA[10a,13] or Oxone ($2KHSO_5 \cdot KHSO_4 \cdot K_2SO_4$).[13b] Both oxidation reactions give **11** in high yield, but the lower cost of Oxone favors this method for large scale preparations. Buffering by $NaHCO_3$ prevents the reaction mixture from becoming acidic, reducing the reactivity of **9** by protonation on nitrogen. A modification of the published procedure[13b] is reported in the experimental section. Functionalization of C4 was accomplished by Katada or Boekelheide rearrangement[22] of **11** and hydrolysis of the acetate intermediate to **12**.[13] Two methods were used to prepare ketone **13** from alcohol **12**: CrO_3/H_2SO_4 in aqueous acetic acid[23] and Swern oxidation.[24] The latter method gave a somewhat cleaner product, but the CrO_3 method is preferred for large scale oxidations. An alternative approach to **13** based on the two-step synthesis of 6,7-dihydroquinolin-8(1*H*)-one from 5,6,7,8-tetrahydroquinoline[25] was also evaluated. Condensation of excess **9** with benzaldehyde gave a mixture of dibenzylidene derivative **14** and the desired monobenzylidene product (**15**)[26] which was ozonized to ketone **13**.

Scheme 3[a]



[a](a) NaH, THF, EtOH, HCO_2Et; (b) TsOH, EtOH; (c) **13**, NaH, THF, EtOH; NH_4OAc, HOAc; (d) *t*-$BuOCH(NMe_2)_2$; (e) **13**, NH_4BF_4, DMF; (f) Me_2NNH_2, EtOH, cyclohexane; Me_3OBF_4, CH_2Cl_2; (g) heat.

Three approaches were used for symmetrical coupling of two molecules of ketone **13** to form heptacyclic terpyridyl **20** (Scheme 3). This transformation is precedented by two syntheses of 5,6,8,9-tetrahydroquino[8,7-*b*]-[1,10]phenanthroline from 6,7-dihydroquinolin-8(1*H*)-one: reaction of the enamine with formaldehyde, followed by cyclization of the intermediate 1,5-diketone with NH_4OAc;[18d] and condensation of the ketone with its β-aminomethylene ketone derivative.[27] The latter method involving a β-heterosubstituted enone is attractive because it offers access to unsymmetrical terpyridyls from two different ketones. Condensation of **13** with ethyl formate gave β-hydroxymethylene ketone **16**, which was converted to β-ethoxymethylene ketone **17**. This intermediate underwent acid-catalyzed condensation with **13** and NH_4OAc to give heptacyclic terpyridyl **20** in 33% yield. Reaction of ketone **13** with NaH and **17**, followed by NH_4OAc, gave **20** in higher yield. An alternative synthesis of **20** involved the reaction of β-dimethylamino

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(26) A lower-yield synthesis of 4-benzylidene-9-methyl-1,2,3,4,5,6,7,8-octahydroacridine (the methyl analogue of **15**) in two steps from the methyl analogue of **7** has been reported: Minaeva, N. N.; Tilichenko, M. N. *Zh. Org. Khim. (Engl. Trans.)* **1986**, *22*, 1720−1724.

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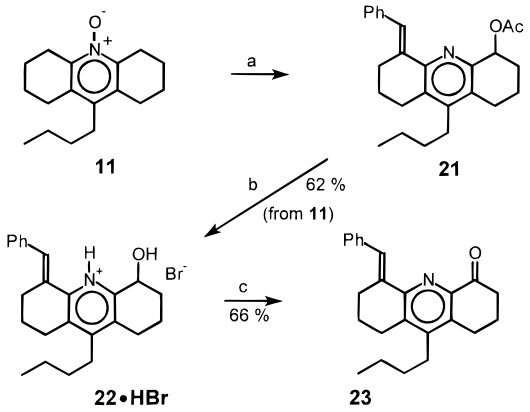
Scheme 4[a]

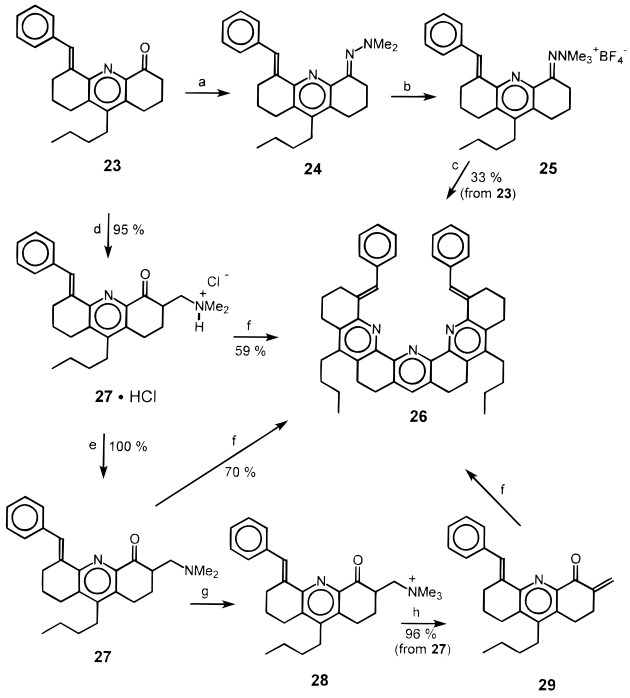


[a](a) Ac_2O, heat; PhCHO, Ac_2O; (b) HBr, H_2O; (c) NaOH, Ac_2O, DMSO.

enone **18**, prepared by condensation of ketone **13** with Bredereck's reagent,[28] with **13** and NH_4BF_4. Though limited to synthesis of symmetrical pyridines, the trimethylhydrazonium tetrafluoroborate pyrolysis method[29] provided the simplest synthesis of **20** from ketone **13**. Quaternization of dimethylhydrazone **19** with trimethyloxonium BF_4^- (rather than methyl iodide[29]) generated the pyrolysis precursor directly, saving an anion exchange step. Batch pyrolysis of **19** yielded **20** in 23% yield overall from **13**.[13a]

Synthesis of pentadentate cleft **6** requires functionalization of both OHA components at both CH_2 groups nearest to nitrogen (positions 4 and 5). One strategy would be to oxidize heptacyclic terpyridyl **20** to diketone **6**, or masked carbonyl groups could be introduced prior to coupling the OHA units. The latter approach could shorten the overall synthesis because benzaldehyde condensation and *N*-oxide rearrangement can be combined in one step.[30] *N*-Oxide **11** is first heated in acetic anhydride, then benzaldehyde is added to form benzylideneacetate **21** (Scheme 4).[7a] Acidic hydrolysis yields benzylidene alcohol **22**, previously isolated as its H_2SO_4 salt.[7a] The procedure has been modified for large scale and ease of separation of **22** from side products, consisting mainly of **14**. Hydrolysis of **21** with aqueous HBr and recrystallization of **22**·HBr affords pure product in higher yield than previously obtained with **22**·H_2SO_4 (43%).[7a] Oxidation of alcohol **22** to ketone **23** was previously carried out in high yield with Dess−Martin periodinane.[31] This hypervalent iodine reagent is reportedly explosive,[32] so alternative methods were sought for large-scale reactions. The CrO_3/H_2SO_4 procedure used for conversion of **12**·H_2SO_4 to **13** was not successful, probably because of the low solubility of **22**·H_2SO_4. Several activated DMSO oxidation methods[33−39] were

Scheme 5[a]



[a](a) Me_2NNH_2, EtOH, cyclohexane; (b) Me_3OBF_4, CH_2Cl_2; (c) heat; (d) Me_2NCH_2Cl, CH_3CN; (e) NaOH, H_2O; (f) **23**, NH_4OAc, DMSO; (g) CH_3I; (h) Et_3N, CH_2Cl_2.

tried, including the following: acetic anhydride,[34] oxalyl chloride,[24,33,35] DCC,[36] P_2O_5,[37] trifluoroacetic anhydride,[38] and phenyl dichlorophosphate.[39] The best results were obtained with the methods of Swern (oxalyl chloride)[35] and Albright−Goldman (acetic anhydride).[34] Yields exceeded 90% with the Swern oxidation, but the latter procedure is better suited to large-scale reactions, since it can be conducted at room temperature and is not very sensitive to the presence of water. Recrystallization removes side products, consisting mainly of **21** and the (methylthio)methyl ether corresponding to alcohol **22**.

The Newkome−Fishel pyrolysis method[29] used for synthesis of heptacyclic terpyridyl **20** (Scheme 3) was also applied successfully to dibenzylidene analogue **26** (Scheme 5). Dimethylhydrazone **24** was quaternized with trimethyloxonium BF_4^- and the trimethylhydrazonium salt **25** was pyrolyzed to give **26**. Attempts to scale-up batch reactions produced **26** in lower yields, apparently because of less efficient removal of volatile byproducts. To overcome this problem, a flow system was developed in which a solution of **25** was added slowly to an inclined, heated tube through which N_2 was passed. Recrystallization of the crude product gave **26** in higher, though variable, yield. The yield of pure **26** was reproducibly

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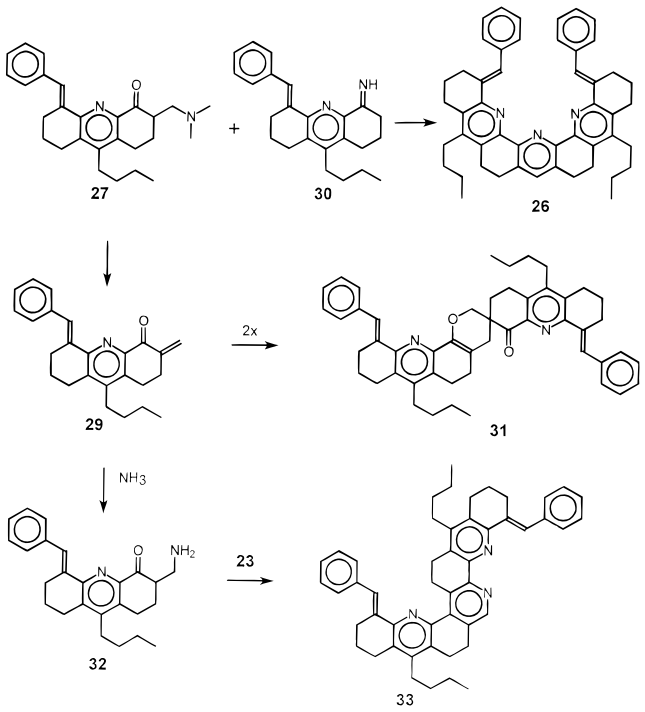
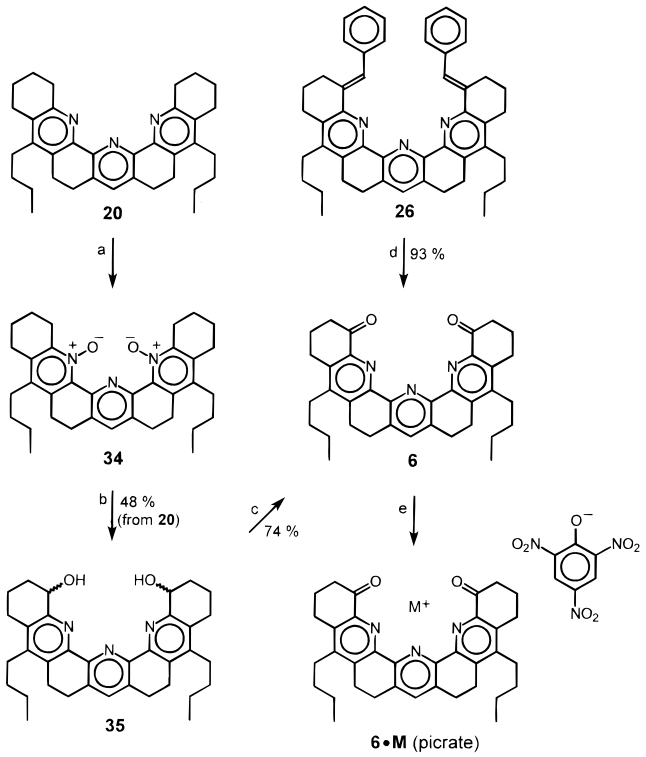


Figure 2. Formation of heptacyclic terpyridyl derivative **26** and side products **31** and **33** in coupling reaction between Manich base **27** and ketone **23**.

improved by treatment of the crude product with hydroxylamine hydrochloride. The synthesis of **26** was greatly improved with Mannich salt **27**·HCl. Despite the previous failure of several methods for preparation of Mannich bases[40] from **23**, reaction with *N*,*N*-dimethyl(methylene)immonium chloride[41] in acetonitrile efficiently gave **27**·HCl. Either **27**·HCl or free base **27** could be condensed with ketone **23** and NH_4OAc by variations of the method of Risch et al.[42] The best yields of **26** were obtained when the reaction was conducted in hot DMSO or pyridine and when ketone **23** was treated with NH_4OAc prior to addition of the Mannich base or salt. Oxidants ($Cu(OAc)_2$, DDQ, Ag_2O, or $Hg(OAc)_2$) did not significantly improve the yield of **26**, despite the required intermediacy of a dihydropyridine. The α-methylene ketone (**29**) was prepared efficiently from **27** by reaction with methyl iodide, followed by triethylamine, but **29** reacted with ketone **23** to give **26** in yields comparable to those of reactions in which this enone was formed in situ from **27** or **27**·HCl.

As a result of efforts to improve the synthesis of **26**, two significant side products were isolated and identified from Mannich condensations: **31**, the spiro-dimer of enone **29** and unsymmetrical S-shaped terpyridyl **33** (Figure 2). Enone dimer **31** was also produced in control experiments in which **27** was heated in DMSO with or without NH_4OAc. The pathways presented in Figure 2 account for the formation of these products and for the

Scheme 6[a]



[a](a) MCPBA, CH_2Cl_2; (b) Ac_2O, AcCl, NaOAc; HCl, H_2O; NaOH, H_2O; (c) Dess-Martin periodinane, H_2SO_4, CH_3CN; $NaHCO_3$, H_2O; (d) O_3, CH_2Cl_2, CH_3OH; Me_2S; (e) M^+ picrate$^-$, $CHCl_3$, H_2O (M = K or Na).

improved yield of **26** when **23** was preheated with NH_4OAc. In this case, imine **30** is apparently formed, and the concentration of NH_4OAc is minimized. Enone **29**, formed by elimination of dimethylamine from **27**, is then trapped more efficiently by reaction with the enamine tautomer of **30**. Unsymmetrical terpyridyl **33** apparently results from condensation of ketone **23** with β-amino enone **32**, which is produced by conjugate addition of ammonia to **29**. Pretreatment of **23** with NH_4OAc reduces the yields of both **31** and **33**, indicating that **33** is not produced from **30** by nucleophilic attack of the imine nitrogen atom at the β-carbon of enone **29**. Similar S-shaped terpyridyls were isolated by Risch et al.[42d] in a study of Mannich condensations of 6,7-dihyroquinolin-8(5*H*)-one with substituted iminium salts, but the role of regioselectivity in the reaction of ammonia with enone intermediates was not discussed.

Diketone **6** was synthesized by two different routes (Scheme 6). Following Thummel's observation that the terminal rings of 2,2′;6′,6″-terpyridine undergo N-oxidation prior to the central ring,[43] we treated heptacyclic terpyridyl **20** with MCPBA. Crude di-*N*-oxide **34** underwent Boekelheide rearrangement,[22] and the resulting diacetate was hydrolyzed to a diastereomeric mixture of diols (**35**). Oxidation of **35** with Dess−Martin periodinane[31] gave diketone **6** in 35% yield overall from **20**. Ozonolysis of dibenzylidene compound **26** gave **6** more efficiently (>90%) and in higher purity than by the former route. Diketone **6** adsorbs strongly to silica gel and alumina in the absence of metal salts. Addition of 2% KI to a 95% ethanol eluent moved **6** off the baseline during TLC on alumina or silica plates; **6** could be

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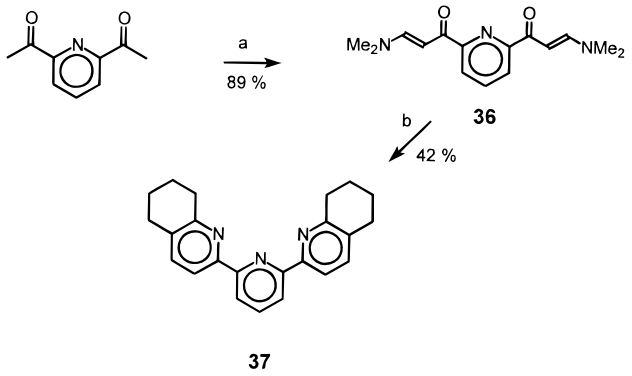
Scheme 7[a]



[a](a) *t*-BuOCH(NMe$_2$)$_2$; (b) cyclohexanone, KO*t*-Bu, THF; HOAc, NH$_4$OAc.

isolated from the ozonolysis product mixture by addition of Ca(OTf)$_2$ and chromatography of the 1:1 complex.

For comparison of complexation properties of preorganized and flexible terpyridyls, 2,6-bis(5,6,7,8-tetrahydroquinol-2-yl)pyridine (**37**) was prepared by an effective synthesis of terpyridyls from ketones.[44] As shown in Scheme 7, 2,6-diacetylpyridine was treated with Bredereck's reagent to afford bis(*β*-dimethylamino enone) **36**. This compound has also been synthesized by reaction of 2,6-diacetylpyridine with DMF dimethylacetal.[45] Reaction of **36** with cyclohexanone enolate, followed by NH$_4$OAc, gave **37**. This sequence demonstrates that Jameson's terpyridine synthesis[44] can be extended from methyl ketones to cyclohexanones and that two pyridine rings can be formed in one step in useful yield.

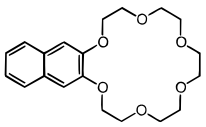
Complexation. Increased chromatographic mobility of diketone **6** in the presence of KI and Ca(OTf)$_2$ suggests that the preorganized cleft of the free ligand has high charge density. The TLC behavior of **6** is opposite that of many host compounds, such as crown ethers, which have higher R_f values as metal-free ligands than as alkali or alkaline earth metal complexes. Strong complexation of a cation apparently reduces the negative charge density of the cleft, and adsorption of the resulting complex is weak in the presence of a lipophilic anion. An alternative explanation is that metal-free **6** is protonated during chromatography and that the resulting salt is more polar than the metal complexes. Sodium and potassium picrate complexes were prepared by extraction of the picrate salts from water into CHCl$_3$ solutions of **6**. The presence of Na$_2$CO$_3$ or K$_2$CO$_3$ in the aqueous layers gave the purest samples of complexes, apparently because host protonation is suppressed. The recrystallized **6**·Na(picrate) and **6**·K(picrate) complexes have 1:1 stoichiometries, while the Ca(OTf)$_2$ complex isolated had 2:1 stoichiometry. Crystals of this complex were not of sufficient quality to allow crystallographic investigation of its structure, but the symmetry exhibited by its ^{1}H NMR spectrum suggests that the two molecules of **6** bind calcium by an equal number of metal−ligand interactions. They may lie in perpendicular or parallel planes, binding calcium in interlocked or stacked arrangements, respectively.

Solution stabilities of the alkali metal complexes of heptacyclic terpyridyls **6** and **20** were estimated by the picrate extraction method.[46] Stability constants of the 1:1 complexes were calculated assuming the absence of any other equilibria in the water-saturated organic phase competing with that represented by eq 1; the results are given in Table 1. Extraction experiments employing flexible terpyridyl **37** did not produce detectible concentrations of picrate in the organic phase, so the stability constants of the alkali metal complexes of **37** cannot exceed 10^3 M^{-1}. For purpose of comparison, the stability constants of alkali metal picrate complexes of 2,3-naphtho-18-crown-6 (**38**)[46b] are also given in Table 1.

Table 1. Stability Constants (log K_s) of Complexes between Hosts and Alkali Metal Picrates in H_2O-Saturated $CHCl_3$[a]

host	Li	Na	K	Rb	Cs
6	8.3	9.7	9.5	8.9	8.1
20	5.2	4.7	4.7	4.3	4.1
37	<3	<8	<3	<3	<3
38[b]	4.4	6.1	7.9	7.1	6.1

[a] The method for estimation of K_s values is described in ref 46. [b] Reference 46b.



38

$$H + G^+ \xrightarrow{K_s} H{\cdot}G^+ \qquad (1)$$

The K_s values for alkali metal complexes of heptacyclic terpyridines **6** and **20** are remarkably high for hosts containing five and three ligand atoms, respectively. Stability constants reported for comparable crown ether complexes containing 5−6 ligating sites generally range from 10^4−10^9 M^{-1}, as exemplified by results for 2,3-naphtho-18-crown-6 (**38**) given in Table 1. In water-saturated chloroform, pentadentate host **6** binds Na$^+$ and K$^+$ more strongly than do most crown ethers.[3j,47] Even tridentate host **20** extracts alkali metal picrates into chloroform, whereas model system **37** is ineffective under the same experimental conditions. Compared with **20**, **37** lacks two butyl chains as well as two six-membered rings. Preorganization of three pyridine rings in **20** might be expected to have a larger effect than substitution of the pyridine rings with alkyl groups. The potent complexation ability of heptacyclic terpyridyl hosts can be attributed to enforced orientation of relatively large ligand functional group dipoles[48] toward the center of the molecular cleft.

Heptacyclic terpyridyl host **6** is somewhat selective for Na$^+$ and K$^+$ relative to Li$^+$, Rb$^+$, and Cs$^+$, but its selectivity curve is relatively flat compared with those of typical crown ethers and cryptands.[47] Tridentate cleft **20** shows measurable selectivity for Li$^+$, but the K_s values of the strongest and weakest complexes vary by only 1

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(48) The dipole moments of pyridine and acetone are 2.2 and 2.9 D, respectively: Weast, R. C.; Ed. *CRC Handbook of Chemistry and Physics*; CRC Press: Boca Raton, FL, 1988; pp E58−60.

order of magnitude. These trends parallel the poor discrimination between alkali metals observed for torand **5**.[7c] The general conclusions are the same as for torand **5**: strong complexation can be achieved with relatively planar preorganized hosts that do not encapsulate the guest; however, encapsulation may be needed for selectivity toward a series of spherical guests of varying radii. Further interpretation of these results must await more detailed thermodynamic and structural investigation of these complexes.

Experimental Section

General Methods. All reactions were conducted under an atmosphere of dry N_2 unless otherwise indicated. Reagent grade solvents were used without purification. Anhydrous solvents were purified as follows: DMSO was distilled from CaH_2 under reduced pressure and collected over activated 4A molecular sieves; CH_2Cl_2, pyridine, and benzene were distilled from CaH_2 under N_2; THF was distilled from Na and benzophenone; acetic anhydride was dried over P_2O_5 and then distilled under reduced pressure.

Melting points are uncorrected. All NMR chemical shifts were measured relative to solvent resonances as indicated and are reported in δ values (ppm); coupling constants are reported in Hz. Infrared frequencies are reported in units of cm^{-1}. UV−visible wavelengths are reported in units of nm. Electron impact mass spectra were recorded at 70 eV. Fast atom bombardment mass spectra were obtained using a *m*-nitrobenzyl alcohol matrix.

9-Butyl-2-hydroxytricyclo[7.2.1.0^{2,7}]tridecan-13-one (7). The condensation of cyclohexanone with *n*-pentanal was conducted according to the published procedure.[13] Recrystallization was carried out by dissolving each gram of crude product in 3 mL of hot methanol, boiling until cloudiness occurred and cooling slowly to 0 °C. The white, crystalline product was dried: mp 140−141 °C (lit.[13c] 141−142 °C); ^{13}C NMR (75 MHz, $CDCl_3$) δ 207.4 (C=O), 77.9 (COH), 59.4, 48.2, 44.8, 42.1, 36.4, 29.1, 28.8, 28.5, 28.2, 26.1, 25.2, 22.5, 20.9, 20.1, 13.7.

8-Butyltricyclo[7.3.1.0^{2,7}]tridec-2(7)-en-13-one (8). A mixture of 4.78 g (18.1 mmol) of keto alcohol **7** and 0.2 mL of a 0.1 M solution of *p*-toluenesulfonic acid monohydrate in ethanol was heated at 210 °C under vacuum (0.1 mm) with distillation of the product through a 16 cm Vigreux column (bp 120−130 °C). Thus 2.59 g (58%) of β,γ-enone **8** was obtained, which crystallized upon standing. An analytical sample was obtained by recrystallization from methanol, mp 52 °C. ^{1}H NMR (80 MHz, $CDCl_3$) δ 2.5 (m, 1 H), 1.9−2.3 (m, 6 H), 1.1−1.9 (m, 16 H), 0.89 (t, J = 6, 3 H); IR (neat) 2930 (s), 2850 (s), 1720 (s), 1680 (s), 1460 (m), 1450 (s), 1390 (s), 1280 (m), 1200 (s), 1160 (m), 1130 (s), 1120 (m), 980 (m), 910 (m), 880 (m); MS (70 eV) *m/z* (rel int) 246 (0.2, M^+), 189 (100, M − C_4H_9). Anal. Calcd for $C_{17}H_{26}O$: C, 82.87; H, 10.63. Found: C, 83.01; H, 10.63.

9-Butyl-1,2,3,4,5,6,7,8-octahydroacridine (9). Method A. The published procedure[13] was used to convert 200 g (0.76 mol) of **7** to 173−177 g (91−96%) of **9**, mp 36−38 °C (lit.[13c] 41−43 °C). ^{13}C NMR (75 MHz, $CDCl_3$) δ 153.5, 148.2, 127.2, 33.0, 30.3, 27.6, 25.6, 23.3, 23.1 22.9, 13.7.

Method B. A mixture of 1.0 g (6 mmol) of 1-morpholinocyclohexene,[49,50] 1.02 g (6.0 mmol) of 2-carbethoxycyclohexanone, and 10 mL of anhydrous xylene was heated under nitrogen at 170 °C for 72 h. The reaction mixture was cooled and solvents were removed in vacuo (1 mm). The resulting yellow oil was diluted with 15 mL of 40% aqueous sodium metabisulfite and 5 mL of ethanol and stirred at room temperature for 1 h. The resulting solids were removed by filtration, and the filtrate was extracted with 20 mL of ether. The organic layer was dried over K_2SO_4 and concentrated to minimum volume in vacuo (25−35 mm). The resulting yellow solid was recrystallized from hexane to afford 1,2,3,4,5,6,7,8-octahydroxanthen-9-one (**10**) as yellow crystals (0.88 g, 72%), mp 130−131 °C (lit.[21b] 131 °C). Of this product, 0.5 g (2.5 mmol) was placed in a flask equipped with a rubber septum. The flask was flushed thoroughly with nitrogen, and freshly distilled anhydrous THF (10 mL) was added by syringe. The resulting solution was stirred at 0 °C as 2.2 mL of a 1.34 M solution of *n*-butyllithium in hexane was added dropwise. Stirring was continued at 0 °C for 3 h after addition was complete. Reaction was quenched by addition of 0.6 mL of acetic acid, and the resulting solution was warmed to room temperature. THF was removed at reduced pressure, and 0.2 g of NH_4OAc (2.6 mmol) and 4 mL of acetic acid were added. The resulting solution was heated at reflux for 2 h and then cooled to room temperature. The mixture was diluted with 10 mL of water, basified (pH 14) with 2 M aqueous NaOH, and extracted with ether (20 mL). The extract was dried ($MgSO_4$) and filtered, and the filtrate was concentrated by rotary evaporation to yield 0.6 g (95%) of the desired product as a beige solid, mp 36−37 °C (lit.[13c] 41−43 °C).

9-Butyl-1,2,3,4,5,6,7,8-octahydroacridine *N*-Oxide (11). The following modification of the published procedure[13c] was employed. A 3 L flask equipped with a mechanical stirrer and reflux condenser fitted with a nitrogen inlet tube was charged with 76 g (0.32 mol) of 9-butyl-1,2,3,4,5,6,7,8-octahydroacridine, 144 g (0.24 mol) of Oxone, 57 g (0.68 mol) of $NaHCO_3$, 1.6 L of methanol, and 480 mL of distilled water. The resulting suspension was stirred at 45−50 °C under nitrogen for 24 h. The inorganic salts were removed from the cooled reaction mixture by vacuum filtration and washed with CH_2Cl_2 (2 × 100 mL). Solvents were removed from the combined filtrates by rotary evaporation and the resulting white suspension was extracted with CH_2Cl_2 (3 × 100 mL). The combined extracts were washed with water (2 × 100 mL) and dried using $MgSO_4$. Filtration and removal of CH_2Cl_2 by rotary evaporation yielded a pale yellow oil. Residual solvent was removed in vacuo (0.5 mm), yielding 80 g (97%) of **11** as a pale yellow, waxy solid, mp 98−99 °C (lit.[13c] 92−94 °C). ^{13}C NMR (75 MHz, $CDCl_3$) δ 145.3, 137.4, 129.9, 30.7, 27.4, 25.7, 25.4, 23.1, 22.2, 21.8, 13.7.

9-Butyl-2,3,5,6,7,8-hexahydroacridin-4(1*H*)-one (13). Method A. A solution of 3.5 mL (40 mmol) of oxalyl chloride (Aldrich, 98%) in 100 mL of anhydrous CH_2Cl_2 was stirred under N_2 at −78 °C as 5.8 mL (81 mmol) of anhydrous DMSO was added by syringe. The resulting mixture was stirred for 30 m at −78 °C, and then a solution of 7.0 g (27 mmol) of 9-butyl-1,2,3,4,5,6,7,8-octahydroacridin-4-ol (**12**)[13] in 20 mL of CH_2Cl_2 was added dropwise. The viscous reaction mixture was stirred for 30 min at −78 °C, 17 mL (0.12 mol) of triethylamine was added, and the cooling bath was removed. The reaction mixture was allowed to warm to room temperature, poured into 25 mL of water, and extracted with CH_2Cl_2 (2 × 25 mL). The combined extracts were washed with pH 7 buffer (3 × 100 mL), dried over Na_2SO_4, and concentrated in vacuo to give 7.8 g of a brown oil. This oil was dissolved in 30 mL of hexanes/ethyl acetate (1:1, v/v) and filtered through 75 g of basic alumina (Fisher, activity I, 80−100 mesh), washing the alumina with additional 1:1 hexane/ethyl acetate. Rotary evaporation gave a yellow oil that solidified on standing in vacuo, yielding 6.75 g (97%) of an off-white solid, mp 64−65 °C. An analytical sample was obtained as a pale orange oil by bulb-to-bulb distillation at 145−150 °C (0.1 mm). ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.01 (m, 2 H), 2.92 (t, J = 6 Hz, 2 H), 2.75 (m, 4 H), 2.61 (t, J = 6 Hz, 2 H), 2.15 (m, 2 H), 1.85 (m, 4 H), 1.45 (m, 4 H), 0.98 (t, J = 7 Hz, 3 H); ^{13}C NMR (75 M Hz, $CDCl_3$) δ 197.2 (C=O), 156.2, 148.5, 144.9, 136.0, 134.4, 38.9, 33.0, 30.0, 27.6, 25.9, 25.1, 22.9, 22.3, 22.13, 22.05, 13.4; IR (KBr) 2950 (s), 2850 (s), 1690 (s), 1560 (s), 1450 (m), 1430 (s), 1340 (m), 1320 (m), 1290 (m), 1240 (s), 1160 (s), 1120 (m), 940 (m), 910 (m), 740 (s); GCMS (70 eV) *m/z* (rel int) 257 (100, M^+), 242 (35, M − CH_3), 228 (63, M − C_2H_5), 214 (46, M − C_3H_7), 200 (80, M − C_4H_7). Anal. Calcd for $C_{17}H_{23}NO$: C, 79.33; H, 9.01; N, 5.44. Found: C, 79.38; H, 8.88; N, 5.19.

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Method B. A solution of CrO_3 in 2:1 (v/v) acetic acid/water (6.0 mL, 24 mmol of CrO_3) was added dropwise over 3 min to a rapidly stirred solution of 7.78 g (30 mmol) of 9-butyl-1,2,3,4,5,6,7,8-octahydroacridin-4-ol (**12**) and 6 mL of concentrated sulfuric acid in 54 mL of glacial acetic acid. The reaction mixture was stirred for 2 h and then diluted with 500 mL of 2 M aqueous sodium acetate and extracted with $CHCl_3$ (3 × 110 mL). The combined extracts were washed with 5% aqueous $NaHCO_3$, dried over Na_2SO_4, and concentrated by rotary evaporation to a red-brown oil. The crude product was dissolved in CH_2Cl_2 and filtered through 100 g of basic alumina (activity II), eluting with 94:6 CH_2Cl_2/acetone. Rotary evaporation gave 7.31 g (95%) of ketone **13** as a light brown oil, which could be further purified as described in method A.

Method C. A solution of 9.16 g (37.7 mmol) of 9-butyl-1,2,3,4,5,6,7,8-octahydroacridine (**9**) and 1.50 mL (14.7 mmol) of benzaldehyde in 18 mL of acetic anhydride was heated under N_2 at 155−160 °C for 16.5 h. Most of the acetic anhydride was removed by distillation in vacuo (25−35 mm), and the residue was dissolved in 20 mL of $CHCl_3$. The resulting solution was washed with 100 mL of 1 M aqueous NaOH, and the aqueous layer was extracted with $CHCl_3$ (2 × 5 mL). The combined organic solutions were distilled under vacuum through a 8 cm Vigreux column, yielding 5.12 g of recovered starting material, bp 120−130 °C (0.2 mm). The residue was dissolved in 12.6 g of acetone, and 2.05 g of concentrated sulfuric acid was added with stirring to precipitate the product. The resulting mixture was stored overnight in a refrigerator. The precipitate was collected by filtration, washed with acetone, and dried in vacuo to yield 4.59 g (63%) of **15**·H_2SO_4, ^{1}H NMR (80 MHz, $CDCl_3$) δ 7.81 (s, 1 H), 7.2−7.5 (m, 5 H), 3.40 (m, 2 H), 2.6−2.9 (m, 8 H), 1.75−1.90 (m, 6 H), 1.3−1.5 (m, 4 H), 0.99 (t, J = 6 Hz, 3 H). This salt was converted to the free base by reaction with 50 mL of 2 M aqueous NaOH and extraction with $CHCl_3$. The combined extracts were washed with saturated aqueous NaCl, dried ($MgSO_4$), and evaporated. A solution of 2.29 g (6.9 mmol) of **15** in 11 mL of $CHCl_2$/methanol (3:1, v/v) was cooled to −42 °C by means of a CH_3CN/CO_2 slush bath. An ozone/oxygen mixture was bubbled through the solution for 2.5 h, and then the solution was purged of ozone by bubbling with N_2 for 1 h. Dimethyl sulfide (1 mL) was added, and the resulting mixture was stored at room temperature for 18 h. Solvents were removed by rotary evaporation, and then the residue was heated at 70−80 °C under vacuum (0.1−1 mm). The crude product was chromatographed on 200 g of silica gel, eluting with CH_2Cl_2/methanol (9:1, v/v), yielding 1.46 g (82%) of ketone **13** as an orange-brown oil.

9-Butyl-3-(hydroxymethylene)-2,3,5,6,7,8-hexahydroacridin-4(1*H*)-one (16). To a solution of 1.10 g (4.3 mmol) of ketone **13** in 15 mL of anhydrous THF were added 0.30 g (12 mmol) of NaH, 0.6 mL (10 mmol) of ethanol, and 1.5 mL (19 mmol) of ethyl formate. The reaction mixture was stirred for 12 h at room temperature, and then solvents were removed by rotary evaporation. The residue was triturated with several portions of pH 7 buffer (125 mL total, 0.25 M capacity) and extracted with $CHCl_3$ (2 × 5 mL). The combined extracts were dried ($MgSO_4$) and evaporated to give 1.21 g of brown oil that rapidly crystallized. Recrystallization from 10 mL of cyclohexane gave 0.73 g (60%) of **16** as reddish-brown needles. An analytical sample was obtained by filtration of an ethyl acetate solution through silica gel followed by recrystallization from cyclohexane, mp 118−119 °C. ^{1}H NMR (80 MHz, $CDCl_3$) δ 9.85 (bs, 1 H), 2.5−3.0 (m, 10 H), 1.7−1.9 (m, 4 H), 1.3−1.5 (m, 4 H), 0.97 (t, J = 6 Hz, 3 H); IR (KBr) 3210 (s), 2940 (s), 2860 (s), 1660 (m), 1650 (s, C=O), 1570 (s), 1570 (s), 1450 (s), 1415 (s), 1385 (s), 1340 (s), 1280 (m), 1240 (m), 1185 (s), 1110 (m), 990 (s), 905 (m), 890 (m), 830 (m), 820 (m), 735 (s), 670 (s). UV−Vis (CH_3OH, $\epsilon \times 10^{-3}$) λ_{max} 236 (10.7), 240 (10.7), 271 (4.1), 281 (4.3), 340 (22.0). Anal. Calcd for $C_{18}H_{23}NO_2$: C, 75.76; H, 8.12; N, 4.96. Found: C, 75.77; H, 8.24; N, 4.83.

5,11-Dibutyl-1,2,3,4,6,7,9,10,12,13,14,15-dodecahydroacridino[4,3-*b*]benzo[*j*][1,10]phenanthroline (20). Method A. A solution of 0.11 g (0.39 mmol) of hydroxymethylene ketone **16** and 92 mg (0.48 mmol) of *p*-toluenesulfonic acid monohydrate in 20 mL of ethanol was heated at reflux for 15 min. The reaction mixture was cooled, diluted with ether, washed with pH 7 buffer (2 × 40 mL) and saturated aqueous NaCl (25 mL), and then dried over $MgSO_4$. Rotary evaporation gave 0.12 g (86%) of ethoxymethylene ketone **17** as a light yellow-brown oil that partially crystallized on standing and slowly decomposed upon exposure to air. A mixture of 38 mg (0.15 mmol) of ketone **13**, 42 mg (0.13 mmol) of ethoxymethylene ketone **17**, 20 mg (0.8 mmol) of NaH, 0.06 mL of ethanol, and 2 mL of anhydrous THF was stirred at room temperature for 19 h. Solvents were removed by rotary evaporation and the residue was dissolved in 10 mL of acetic acid with 0.52 g (6.8 mmol) of ammonium acetate. The resulting solution was stirred under reflux for 7.5 h and then concentrated to dryness by rotary evaporation. The residue was triturated with 2 M aqueous NaOH and extracted with $CHCl_3$ (2 × 2 mL). The combined extracts were dried ($MgSO_4$) and rotary evaporated, leaving a glassy orange-brown residue. Chromatography with neutral alumina (activity grade II), eluting with CH_2Cl_2/ethyl acetate (1:1, v/v) gave 31 mg (43%) of **20** as straw-colored crystals.

Method B. A mixture of 2.82 g (11.0 mmol) of ketone **13** and 4.0 mL of *tert*-butoxybis(dimethylamino)methane (Bredereck's reagent, Aldrich) was heated at 70 °C for 3 h. The cooled mixture was diluted with benzene and washed with 50 mL of 5% aqueous $NaHCO_3$ and then with 50 mL of pH 7 buffer. Rotary evaporation gave 3.14 g (92%) of crude **18** as a brown oil, which can be purified by chromatography on silica gel, eluting with benzene/ethanol/triethylamine (85:15:15, v/v). ^{1}H NMR (80 MHz, $CDCl_3$) δ 7.70 (s, 1 H), 3.10 (s, 6 H), 2.5−3.4 (m, 10 H), 1.7−1.9 (m, 4 H), 1.3−1.5 (m, 4 H), 0.96 (t, J = 6 Hz, 3 H). MS (70 eV) *m*/*z* (rel int) 312 (54, M^+), 311 (35, M − 1), 197 (30, M − CH_3), 268 (76, M − NMe_2). A solution of 2.45 g (9.5 mmol) of ketone **13**, 3.14 g (10.1 mmol) of crude **18** and 5 g (50 mmol) of ammonium tetrafluoroborate in 15 mL of dimethylformamide was stirred at 150 °C for 15 min. An additional 1 g (10 mmol) of ammonium tetrafluoroborate was added, and the reaction mixture was stirred a further 65 min at 150 °C. The cooled reaction mixture was diluted with 150 mL of benzene/chloroform (9:1, v/v), washed with 0.5 M aqueous NaOH (2 × 200 mL), and dried over $MgSO_4$. Rotary evaporation left a dark brown glass that was dissolved in ethyl acetate. After standing for several hours, this solution was filtered to collect a precipitate, which was washed with ethyl acetate. The solid was dissolved in CH_2Cl_2, and a small amount of undissolved material was removed by filtration. The filtrate was rotary evaporated, and the residue was recrystallized from ethanol to give 1.31 g (26%) of **20** as yellow-orange needles.

Method C. A solution of 4.76 g (18.5 mmol) of ketone **13**, 8 mL (105 mmol) of 1,1-dimethylhydrazine, 10 mL of ethanol, and 30 mL of cyclohexane was stirred at room temperature for 13 h. Solvents were removed by rotary evaporation, 30 mL of benzene was added, and the solution was dried by azeotropic distillation using a Dean−Stark apparatus. Rotary evaporation gave the solid dimethylhydrazone, which was dissolved in 40 mL of anhydrous CH_2Cl_2. Trimethyloxonium tetrafluoroborate (2.73 g, 18.4 mmol) was added, and the reaction mixture was stirred at room temperature for 25 min. Dichloromethane was removed by rotary evaporation without heating, and the flask containing the orange glassy residue of trimethylhydrazonium salt **19** was placed in a 200 °C oil bath for 6 min. During this period the viscous pyrolysis mixture, which was stirred under a stream of N_2, turned dark and evolved gas. A solution of the cooled reaction mixture in 40 mL of $CHCl_3$ was washed with 40 mL of 2 M aqueous NaOH, dried ($MgSO_4$), and evaporated. The resulting dark glassy residue was triturated with 20 mL of ethyl acetate, causing precipitation of the product over a period of 24 h. The solid was collected by filtration, washed with ethyl acetate, and recrystallized from ethanol to give 1.15 g (23%) of **20** as straw-colored needles, mp 220−221 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.36 (s, 1 H), 3.15−3.25 (m, 4 H), 2.92 (m, 8 H), 2.86 (bs, 3 H), 2.79 (m, 4 H), 2.64 (t, J = 6 Hz, 4 H), 1.8−1.9 (m, 8 H),

1.35−1.54 (m, 8 H), 0.98 (t, J = 6 Hz, 3 H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 155.6, 150.7, 148.4, 147.4, 134.3, 132.8, 130.3, 129.1, 32.4, 30.9, 27.9, 27.5, 26.1, 23.5, 23.1, 23.0, 22.6, 13.8. IR (KBr) 3340 (m), 2950 (s), 2855 (s), 1557 (s), 1432 (m), 1390 (m), 1243 (s), 1140 (m), 960 (m). UV−Vis (95% ethanol, $\epsilon \times 10^{-3}$) λ_{max} 245 (22), 297 (10), 306 (14), 346 (24). MS (70 eV) *m*/*z* (rel int) 505 (100, M^+). Anal. Calcd for $C_{35}H_{43}N_3 \cdot (H_2O)_{1.5}$: C, 78.90; H, 8.70; N, 7.89. Found: C, 78.73; H, 8.68; N, 7.65.

5-Benzylidene-9-butyl-1,2,3,4,5,6,7,8-octahydroacridin-4-ol Hydrobromide (22·HBr). To a 1-L flask equipped with a magnetic stirring bar, reflux condenser, and a 500 mL addition funnel were added 38.9 g (0.15 mol) of 9-butyl-1,2,3,4,5,6,7,8-octahydroacridine *N*-oxide (**11**) and 300 mL of acetic anhydride. The apparatus was flushed with nitrogen, and the reaction mixture was heated by means of a 110 °C oil bath for 1 h. Benzaldehyde (100 mL, 104 g, 1 mol) was added in one portion, and the resulting solution was heated at reflux for 14 h (prolonged heating causes formation of a side-product). The condenser was replaced with a simple distillation apparatus, and the mixture was concentrated by vacuum distillation at 2−35 mm pressure (the still head temperature should not exceed 45 °C at 5 mmHg), collecting 330−340 mL of distillate in a receiving flask cooled by dry ice/acetone. Methanol (300 mL) and concentrated hydrobromic acid (100 mL, 48% aqueous) were added to the brown residue, and the resulting solution was heated under reflux for 4−6 h. The reaction mixture was allowed to cool to room temperature, 300 mL of water was added, and most of the methanol was removed by rotary evaporation. The resulting aqueous mixture was extracted with CH_2Cl_2 (2 × 200 mL). The combined extracts were dried (Na_2SO_4) and concentrated by rotary evaporation. The resulting dark oil was triturated with 200 mL of acetone to yield **22**·HBr in two crops as a bright yellow solid (40 g, 62%), mp 180−182 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.52 (s, 1 H), 7.36−7.62 (m, 5 H), 6.29 (d, J = 5 Hz, 1 H), 5.56 (m, 1 H), 2.71−2.95 (m, 8 H), 1.92−2.18 (m, 6 H), 1.46−1.49 (m, 4 H), 1.01 (t, J = 7 Hz, 3 H). IR (KBr) 3440 (m), 3257 (s), 2952 (m), 2867 (s), 1613 (s), 1584 (m), 1505 (w), 1436 (w), 1412 (w), 1354 (m), 1329 (m), 1259 (w) 1198 (m), 767 (m), 698 (m). ^{13}C NMR (75 MHz, $CDCl_3$) δ 159.4, 151.5, 146.0, 135.9, 135.1, 133.3, 132.3, 130.2, 128.5, 128.2, 126.7, 63.4, 29.6, 29.3, 29.1, 26.4, 25.4, 25.3, 23.1, 21.6, 18.6, 13.5.

5-Benzylidene-9-butyl-1,2,3,4,5,6,7,8-octahydroacridin-4-ol (22). A solution of 40 g (9.3 mmol) of **22**·HBr in 200 mL of CH_2Cl_2 was stirred vigorously with 200 mL of 1 M aqueous NaOH for 1 h. The organic phase was dried ($MgSO_4$) and concentrated by rotary evaporation. The resulting pale yellow oil was triturated with hexanes to yield 29.8 g (93%) of alcohol **22** as a pale yellow solid, mp 94−95 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.94 (s, 1 H), 7.35−7.43 (m, 4 H), 7.31 (t, J = 6 Hz, 1 H), 4.66 (dd, J = 5, 9 Hz, 1 H), 4.59 (s, 1 H), 2.74−2.89 (m, 6 H), 2.55 (m, 2 H), 2.35 (m, 1 H), 2.06 (m, 1 H), 1.80−1.87 (m, 4 H), 1.43 (m, 4 H), 0.98 (t, J = 6 Hz, 3 H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 154.8, 148.9, 148.6, 137.8, 135.6, 129.4, 129.2, 127.8, 127.5, 126.3, 125.9, 69.3, 30.22, 27.9, 25.8, 25.5, 23.1, 22.8, 19.5, 13.6. IR (KBr) 3412 (m), 2931 (s), 2848 (s), 1590 (w), 1554 (s), 1384 (s), 1090 (s), 1061 (s), 749 (m), 690 (s). Anal. Calcd for $C_{24}H_{29}NO$: C, 82.95; H, 8.41; N, 4.03. Found: C, 82.79; H, 8.45; N, 3.80.

5-Benzylidene-9-butyl-2,3,5,6,7,8-hexahydroacridin-4(1*H*)-one (23). A mixture of 95 g (0.27 mol) of alcohol **22** and 560 mL of DMSO was stirred at 40−45 °C under N_2 until the solid dissolved. The solution was cooled to room temperature, acetic anhydride (400 mL) was added, and stirring was continued at room temperature for 16 h. The reaction mixture was transferred to a 4 L Erlenmeyer flask and diluted with water (3 L) using an ice bath to minimize heating. The resulting mixture was stirred at room temperature for 7 h and then filtered. The residue was washed with water (2 × 150 mL) and dried in air. A solution of the crude product in 300 mL of $CHCl_3$ was washed with 2% aqueous Na_2CO_3 solution (2 × 150 mL) and then with 150 mL of water and dried ($MgSO_4$). Filtration and rotary evaporation gave a residue, which was dissolved in hot ethyl acetate (450 mL). Hexane (200 mL portions) was added to the boiling ethyl acetate solution until it became cloudy. The resulting mixture was allowed to stand at room-temperature overnight, and then the precipitate was collected by vacuum filtration and washed with hexane (2 × 100 mL). Drying under vacuum (1 mm) gave 67.1 g (71%) of **23** as a cream-colored solid, mp 120−121 °C. An analytical sample was obtained by slow evaporation of a solution in methanol/water (10:1, v/v), mp 121−122 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.08 (s, 1 H), 7.31−7.39 (m, 4 H), 7.23 (t, J = 7 Hz, 1 H), 2.97 (t, J = 6.2 Hz, 2 H), 2.82−2.88 (m, 4 H), 2.76 (t, J = 6.3 Hz, 2 H), 2.66 (m, 2 H), 2.16 (m, 2 H), 1.84 (m, 2 H), 1.45 (m, 4 H), 0.98 (t, J = 7 Hz, 3 H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 197.3, 152.0, 148.8, 145.6, 137.8, 136.9, 135.3, 134.6, 129.6, 128.2, 127.8, 126.5, 39.4, 30.5, 28.2, 27.4, 26.7, 25.8, 23.2, 22.5, 22.3, 13.8. IR (KBr) 3019 (w), 2947 (s), 2865 (m), 2832 (m), 1698 (s), 1559 (m), 1488 (m), 1443 (m), 1424 (m), 1388 (m), 1335 (m), 1213 (m), 1174 (s), 1134 (m), 966 (m), 766 (m), 701 (s). UV−Vis (CH_3OH, $\epsilon \times 10^{-3}$) λ_{max} 223 (21), 265 (sh, 16), 293 (24). MS (70 eV) *m*/*z* (rel int) 345 (56, M^+), 344 (100, M − 1). Anal. Calcd for $C_{24}H_{27}NO$: C, 83.43; H, 7.88; N, 4.06. Found: C, 83.35; H, 7.97; N, 3.97.

5-Benzylidene-9-butyl-3-[(*N*,*N*-dimethylamino)methyl]-2,3,5,6,7,8-hexahydroacridin-4(1*H*)-one Hydrochloride (27·HCl). A mixture of 3.0 g (0.87 mmol) of ketone **23**, 1.24 g (13.3 mmol) of *N*,*N*-dimethyl(methylene)ammonium chloride (Aldrich), and 56 mL of acetonitrile was stirred under N_2 at room temperature for 24 h. The resulting precipitate was collected by vacuum filtration and washed with ethyl acetate (2 × 25 mL), yielding 3.77 g (95%) of Mannich salt **27**·HCl as a white solid. Slow evaporation of a solution in CH_2Cl_2/ethyl acetate gave a sample which was dried in vacuo for 18 h at room temperature, mp 156−157 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.90 (s, 1 H), 7.3−7.4 (m, 4 H), 7.17 (t, J = 6.3, 1 H), 3.81 (dd, J = 5, 13 Hz, 1 H), 3.27 (dd, J = 5, 10 Hz, 1 H), 3.03−3.13 (m, 3 H), 2.87 (s, 6 H), 2.52−2.63 (m, 4 H), 1.94 (m, 2 H), 1.77 (m, 2 H), 1.36 (m, 4 H), 0.90 (t, J = 6 Hz, 3 H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 195.8, 152.2, 149.0, 144.3, 137.3, 136.5, 135.3, 135.1, 129.3, 128.1, 127.8, 126.6, 57.7, 44.8, 44.4, 30.1, 28.0, 27.9, 27.1, 26.4, 24.9, 23.0, 22.1, 14.0. IR (KBr) 3430 (s), 3018 (w), 2941 (s), 2692 (m), 1695 (s), 1388 (s), 1149 (m), 1090 (m), 764 (m), 955 (s).

5-Benzylidene-9-butyl-3-[(*N*,*N*-dimethylamino)methyl]-2,3,5,6,7,8-hexahydroacridin-4(1*H*)-one (27). A mixture of 0.13 g (0.29 mmol) of **27**·HCl, 30 mL of CH_2Cl_2, and 40 mL of 1 M aqueous NaOH solution was stirred vigorously for 1 h. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2 × 15 mL). The combined organic solutions were dried ($MgSO_4$) and filtered, and the filtrate was concentrated to dryness in vacuo at room temperature. Residual solvent was removed at 0.5 mmHg, yielding 0.12 g (100%) of Mannich base **27** as a colorless solid, mp 99−100 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.09 (s, 1 H), 7.20−7.43 (m, 5 H), 3.07 (m, 1 H), 2.93 (m, 1 H), 2.86 (m, 4 H), 2.80 (m, 1 H), 2.78 (m, 2 H), 2.65 (t, J = 6 Hz, 2 H), 2.44 (m, 1 H), 2.28 (s, 6 H), 1.96 (m, 1 H), 1.84 (m, 2 H), 1.46 (m, 4 H), 0.98 (t, J = 6 Hz, 3 H). ^{13}C NMR ($CDCl_3$, 75 MHz) δ 198.3, 152.1, 148.7, 145.6, 137.9, 136.1, 135.3, 134.4, 129.6, 128.3, 127.9, 126.5, 58.6, 46.3, 45.7, 30.5, 28.0, 27.4, 26.6, 25.9, 24.2, 23.2, 22.5, 13.7. IR (KBr) 3401 (w), 3048 (w), 3001 (w), 2931 (s), 2919 (s), 2801 (s), 2757 (s), 1698 (s), 1554 (m), 1460 (m), 1437 (m), 1378 (m) 1261 (m), 1150 (m), 1031 (m), 716 (m), 690 (m). Anal. Calcd for $C_{27}H_{34}N_2O$: C, 80.55; H, 8.51. Found: C, 80.35; H, 8.46.

5-Benzylidene-9-butyl-3-methylene-2,3,5,6,7,8-hexahydroacridin-4(1*H*)-one (29). A mixture of 4.34 g (11 mmol) of Mannich base **27** and 24 mL (55 g, 0.39 mol) of CH_3I was stirred at room temperature for 30 min, and then excess CH_3I was removed by rotary evaporation. The resulting pale yellow solid (quaternary ammonium salt **28**) was dissolved in 220 mL of CH_2Cl_2. The solution was stirred at room temperature as 10 mL (7.3 g, 72 mmol) of triethylamine was added in one portion. The solution became cloudy within a few minutes due to the precipitation of triethylammonium iodide. After 10 min the reaction mixture was shaken with 100 mL of H_2O, and the organic layer was separated, dried (Na_2SO_4), and concentrated by rotary evaporation. The residual off-white solid was

dried in vacuo for 12 h, yielding 3.78 g (96%) of enone **29**, mp 110−111 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.14 (s, 1 H), 7.33−7.44 (m, 4 H), 7.24 (t, J = 6 Hz, 1 H), 6.28 (s, 1 H), 5.48 (s, 1 H), 3.00 (t, J = 6 Hz, 2 H), 2.88 (m, 6 H), 2.67 (m, 2 H), 1.86 (m, 2 H), 1.46 (m, 4 H), 0.99 (t, J = 7 Hz, 3 H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 186.5, 152.8, 148.3, 146.5, 143.4, 138.1, 136.4, 135.3, 134.5, 129.7, 128.7, 128.0, 126.6, 121.5, 30.9, 30.8, 28.1, 27.5, 26.9, 25.3, 23.1, 22.6, 13.7.

1,15-Dibenzylidene-5,11-dibutyl-1,2,3,4,6,7,9,10,12,13,14,15-dodecahydroacridino[4,3-*b*]benzo[*j*][1,10]-phenanthroline (26). Method A. A solution of 14.6 g (42.3 mmol) of ketone **23**, 30 mL (0.39 mol) of 1,1-dimethylhydrazine, 30 mL of ethanol, and 90 mL of cyclohexane was heated under reflux for 1 h with the reflux solvent passing through a Soxhlet extractor containing 3A molecular sieves. The solvents were evaporated in vacuo, and the residual viscous brown oil was dissolved in 50 mL of benzene. Rotary evaporation was repeated to remove remaining water and 1,1-dimethylhydrazine. A solution of the residue in CH_2Cl_2 was filtered through Woelm neutral alumina (150 g, activity II), washing with 200 mL of CH_2Cl_2. To the resulting yellow solution of hydrazone **24** was added 6.15 g (41.6 mmol) of trimethyloxonium tetrafluoroborate, and the resulting mixture was stirred at room temperature for 40 min. The resulting dark orange solution of salt **25** in CH_2Cl_2 was added over a period of 90 min to a Pyrex glass tube inclined at an angle of 30° and heated at 235−240 °C along a path length of 31 cm by means of a tube furnace, while N_2 gas was flowing through the tube at a rate of approximately 1 L/min. The viscous product mixture collected at the exit of the tube was dissolved in 60 mL of $CHCl_3$. This solution was washed with 1 M aqueous NaOH (100 mL), dried (Na_2SO_4), and concentrated in vacuo to a dark brown glass. This residue was dissolved in 100 mL of ethyl acetate. After standing for 24 h, this solution deposited a precipitate, which was collected by vacuum filtration and washed thoroughly with ethyl acetate. This first crop was dried in air to give 2.45 g of **26** as a pale yellow powder, which was pure according to its ^{1}H NMR spectrum. The mother liquor was evaporated to dryness. A mixture of the residue with 20 g (0.29 mol) of hydroxylamine hydrochloride and 200 mL of ethanol was heated at reflux under N_2 for 5.5 h. The ethanol solution was decanted from excess hydroxylamine hydrochloride, which crystallized when the reaction mixture was cooled. The supernatant was diluted with 500 mL of 1 M aqueous HCl, and the resulting solution was extracted with $CHCl_3$ (2 × 75 mL). The combined extracts were washed with 1 M aqueous NaOH (100 mL), dried ($MgSO_4$), filtered, and evaporated. A solution of the resulting dark brown glass in ethyl acetate (100 mL) was allowed to stand for 24 h, and a second crop of **26** (2.40 g) was collected, washed with ethyl acetate, and dried in air. The combined yield was 4.85 g (33%) of relatively pure material that could be converted directly to diketone **6**. An analytical sample was obtained by recrystallization from benzene and dried in vacuo for 12 h at room temperature, mp 256−258 °C.

Method B. A mixture of 0.10 g (0.29 mmol) of ketone **23**, 0.03 g (0.39 mmol) of ammonium acetate, and DMSO (6 mL) was heated at 85 °C for 5 min. A solution of 0.12 g (0.29 mmol) of 5-benzylidene-9-butyl-3-[(*N*,*N*-dimethylamino)methyl]-2,3,5,6,7,8-hexahydroacridin-4(1*H*)-one (**27**) in 4 mL of pyridine was added to the preheated reaction mixture, and heating was continued at 85 °C for an additional 1 h. The reaction mixture was allowed to cool to room temperature, diluted with CH_2Cl_2 (30 mL), and extracted with 1 M aqueous NaOH (4 × 30 mL), followed by water (30 mL). The aqueous solutions were combined and washed with CH_2Cl_2 (20 mL). The combined organic layers were dried ($MgSO_4$), filtered, and concentrated in vacuo. The resulting brownish yellow glass was triturated with ethyl acetate (15 mL), yielding 0.14 g (70%) of **26** as a pale yellow solid.

Method C. To a three-necked round-bottomed flask fitted with a magnetic stirrer, thermometer, and a condenser with a nitrogen inlet tube were added 6.22 g (18 mmol) of ketone **23**, 2.08 g (27 mmol) of ammonium acetate, and 175 mL of DMSO. The mixture was heated at 80 °C until all solids completely dissolved (5−10 m). 5-Benzylidene-9-butyl-3-[(*N*,*N*-dimethylamino)methyl]-2,3,5,6,7,8-hexaydroacridin-4(1*H*)-one HCl salt (**27**·HCl, 7.91 g, 18 mmol) was added to the solution, and heating was continued at 80 °C. The Mannich salt dissolved, and a precipitate formed within several minutes. The reaction mixture was heated briefly to 110 °C, and then it was allowed to cool to room temperature. The precipitate was collected by vacuum filtration, washed with ethyl acetate, and dried in vacuo, yielding 8.26 g (67%) of crude **26**. The crude product was dissolved in 40 mL of CH_2Cl_2 and precipitated by addition of 300 mL of ethyl acetate. The precipitate was collected by filtration and dried in vacuo, yielding 7.22 g (59%) of pure **26**. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.30 (s, 2 H), 7.41 (s, 1 H), 7.24 (m, 4 H), 7.11 (m, 6 H), 2.94 (s, 8 H), 2.78−2.86 (m, 8 H), 2.67 (t, J = 6 Hz, 4 H), 1.83 (quin, J = 6 Hz, 4 H), 1.45 (m, 8 H), 0.97 (t, J = 6 Hz, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 152.0, 151.6, 149.5, 146.6, 138.7, 140.0, 134.3, 133.4, 130.6, 130.5, 129.7, 127.6, 125.8, 31.1, 28.2, 27.9, 27.6, 26.7, 24.0, 23.1, 23.0, 13.9. IR (KBr) 3070 (w), 3030 (w), 2950 (s), 2860 (m), 1600 (w), 1550 (m), 1440 (s), 1380 (s), 1240 (m), 1180 (m). Anal. Calcd for $C_{49}H_{51}N_3$: C, 86.30; H, 7.54; N, 6.16. Found: C, 86.04; H, 7.56; N, 5.86.

1,11-Dibenzylidene-5,15-dibutyl-1,2,3,4,6,7,11,12,13,14,16,17-dodecahydroacridino[3,4-*c*]benzo[*j*][1,10]-phenanthroline (33). Ketone **23** (0.10 g, 0.29 mmol) was converted to **26** by method C, as described above. After collection of the precipitate from the reaction mixture, the filtrate was concentrated by rotary evaporation and chromatographed (neutral alumina, hexanes/EtOAc, 1:1 (v/v)), yielding 0.01 g (4%) of **33** as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.64 (s, 1 H), 8.21 (s, 1 H), 8.04 (s, 1 H), 7.21−7.45 (m, 10 H), 3.79 (t, J = 6 Hz, 2 H), 2.88−2.92 (m, 14 H), 2.70−2.72 (m, 4 H), 1.84−1.97 (m, 4 H), 1.47−1.49 (m, 8 H), 0.96−1.00 (m, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 152.8, 151.2, 149.6, 149.1, 149.0, 148.8, 148.4, 139.6, 138.7, 138.2, 136.2, 133.3, 131.8, 131.6, 130.8, 130.5, 130.3, 129.6, 129.4, 129.4, 128.1, 127.8, 127.6, 126.8, 126.4, 125.0, 125.0, 31.4, 31.2, 31.1, 28.1, 27.9, 27.5, 26.4, 26.2, 26.0, 24.4, 24.2, 23.0, 22.9, 22.6, 22.3, 13.9, 13.8. IR (KBr) 3050 (w), 2954 (s), 1550 (m), 1491 (m), 1443 (m), 1390 (m), 1290 (m), 908 (m), 729 (m), 697 (m), 641 (m). Anal. Calcd for $C_{49}H_{51}N_3$: C, 86.30; H, 7.54; N, 6.16. Found: C, 86.21; H, 7.75; N, 5.92.

3,4-(5-Benzylidene-9-butyl-1,2,5,6,7,8-hexahydroacridino[4,3-*c*])-8,9-(8-benzylidene-4-butyl-5,6,7,8-tetrahydroquino[8,9-*f*])-2-oxaspiro[5.5]undeca-3,8-dien-7-one (31). The chromatogram used to isolate side product **33** described above also yielded spiro-dimer **31** as a pale yellow solid (ca. 4% of the crude product by ^{1}NMR spectroscopy). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.06 (s, 1 H), 7.71 (s, 1 H), 7.2−7.4 (m, 10 H), 3.55 (m, 1 H), 2.0−3.0 (m, 23 H), 1.80 (m, 4 H), 1.31−1.41 (m, 8 H), 0.94 (m, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 194.2, 152.1, 148.7, 148.2, 146.5, 146.0, 145.0, 143.2, 138.7, 138.0, 136.6, 136.0, 135.4, 134.3, 129.6, 129.3, 128.7, 128.0, 127.9, 127.7, 127.7, 126.4, 125.9, 125.4, 111.7, 76.3, 33.4, 31.06, 29.9, 27.8, 27.9, 27.8, 27.3, 27.3, 26.7, 26.2, 26.1, 23.5, 23.1, 23.0, 22.9, 22.9, 22.4, 21.6, 13.7, 13.5. Anal. Calcd for $C_{50}H_{54}N_2O_2$: C, 83.99; H, 7.61; N, 3.92. Found: C, 83.65; H, 7.59; N, 3.89.

5,11-Dibutyl-2,3,4,6,7,9,10,12,13,14-decahydroacridino[4,3-*b*]benzo[*j*][1,10]phenanthroline-1,15-dione (6). Method A. An ozone/oxygen mixture was bubbled through a −70 °C solution of 7.0 g (10.3 mmol) of dibenzylidene terpyridyl derivative **26** in 200 mL of dichloromethane/methanol (3:1, v/v). During the first 10 min, the color of the solution changed from brown to light yellow and then to yellow-green at the end of the reaction period (50 min). Nitrogen was bubbled through the cold solution for 10 min, and then 6 mL of dimethyl sulfide was added. The resulting mixture was allowed to warm to room-temperature overnight and then concentrated to minimum volume in vacuo at ca. 30 °C. A solution of the residue in 10 mL of CH_2Cl_2 was added dropwise to 400 mL of ether with rapid stirring. The resulting precipitate was collected by vacuum filtration, washed with ether (40 mL), and dried at 90 °C for 2 h to yield 4.45 g (81%) of **6** as a beige solid. A second crop (0.66 g, 12%) was obtained by slow evaporation of the mother liquor. A sample for microanalysis

was recrystallized from freshly distilled *n*-butyronitrile, washed with acetone, and dried in vacuo at 60 °C for 12 h, mp 270−275 °C dec. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.42 (s, 1 H), 4.46 (s, 2 H), 2.95−3.03 (m, 12 H), 2.76 (m, 8 H), 2.19 (m, 4 H), 1.47 (m, 8 H), 0.98 (t, J = 7 Hz, 6 H). IR (KBr) 3400 (b), 2950 (s), 2860 (s), 1695 (s), 1650 (sh), 1560 (s), 1540 (sh), 1450 (sh), 1430 (s), 1410 (sh), 1380 (s), 1340 (sh), 1330 (m), 1270 (sh), 1220 (s), 1180 (s), 1130 (sh), 1100 (w), 1030 (m), 980 (w), 940 (w), 890 (w). UV−Vis (CH_3CN, $\epsilon \times 10^{-3}$) λ_{max} 237 (55.3), 310 (18.4), 344 (18.0). Anal. Calcd for $C_{35}H_{39}N_3O_2 \cdot 2H_2O$: C, 73.78; H, 7.61; N, 7.38. Found: C, 73.92; H, 7.61; N, 7.44.

Method B. A solution of 0.57 g (1.1 mmol) of heptacyclic terpyridyl **20**, 1.11 g (7.3 mmol) of 85% *m*-chloroperoxybenzoic acid, and 11 mL of CH_2Cl_2 was stirred at room temperature for 75 min. The reaction mixture was washed with 1 M aqueous NaOH (2 × 40 mL), dried ($MgSO_4$), and concentrated in vacuo, yielding crude di-*N*-oxide **34** as a light brown glass. (**Note**: incomplete removal of MCPBA at this stage could lead to the formation of potentially **explosive** diacetyl peroxide in the next step.) A solution of this intermediate, 5 mL of acetic anhydride, and 0.16 mL of acetyl chloride was stirred for 15 min at room temperature, 0.30 g (3.7 mmol) of sodium acetate was added, and the resulting mixture was stirred at 100 °C for 1 h. Most of the acetic anhydride was removed from the cooled reaction mixture by rotary evaporation. A solution of the residue in 5 mL of CH_2Cl_2 was shaken with 25 mL of 2 M aqueous NaOH, saturated aqueous NaCl was added, the layers were separated, and the organic layer was dried ($MgSO_4$). Evaporation gave a brown solid, which was chromatographed using 70 g of neutral alumina (Act. II), eluting with CH_2Cl_2/acetone (3:2, v/v). Thus 0.44 g (66%) of 5,11-dibutyl-1,2,3,4,6,7,9,10,12,13,14,15-dodecahydroacridino[4,3-*b*]benzo[*j*]-[1,10]phenanthroline-1,15-diol diacetate was obtained as a light tan powder (mixture of diastereomers). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40 (s, 1 H), 6.03 (m, 2 H), 2.85−3.00 (m, 8 H), 2.60−2.75 (m, 8 H), 2.18 (s, 3 H), 2.17 (s, 3 H), 1.85−2.30 (m, 8 H), 1.40−1.55 (m, 8 H), 0.98 (m, 6 H). A solution of 0.44 g (0.70 mmol) of this intermediate and 9 mL of 2 M aqueous HCl was heated under reflux for 85 min. The resulting orange solution was cooled to room temperature, made basic with 20 mL of 2 M aqueous NaOH and extracted with $CHCl_3$ (3 × 7 mL). The combined extracts were dried ($MgSO_4$) and concentrated in vacuo. The residue was washed with benzene and dried in air, yielding 0.27 g (72%) of 5,11-dibutyl-1,2,3,4,6,7,9,10,12,13,14,15-dodecahydroacridino[4,3-*b*]benzo[*j*]-[1,10]phenanthroline-1,15-diol (**35**) as a tan powder (mixture of diastereomers). ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.41 (s, 1 H), 4.95−5.0 (m, 2 H), 3.8 (bs, 2 H), 2.95 (m, 8 H), 2.5−3.0 (m, 8 H), 1.7−2.2 (m, 8 H), 1.45−1.5 (m, 8 H), 0.97 (m, 6 H). A solution of 0.25 g (0.47 mmol) of this intermediate, 0.42 mL of a 1.1 M solution of H_2SO_4 in CH_3CN, and 5 mL of CH_3CN was stirred as 0.51 g (1.2 mmol) of Dess−Martin periodinane (**Caution:** explosion hazard)[32] was added in one portion. The resulting suspension was stirred at room temperature for 10 min, resulting in a cloudy yellow solution, which was diluted with 10 mL of 1 M aqueous $NaHCO_3$ and 10 mL of 1 M aqueous $Na_2S_2O_3$. The resulting mixture was extracted with $CHCl_3$ (2 × 7 mL), and the combined extracts were dried ($MgSO_4$) and evaporated in vacuo. The brown, glassy residue was dissolved in 1.5 mL of acetone. The product crystallized from this solution at room temperature; it was collected by filtration and washed with acetone. A small second crop was collected from the mother liquor, yielding a total of 197 mg (74%) of diketone **6** as a greenish-brown solid, mp 180−190 °C dec. According to its ^{1}H NMR spectrum, this product was less pure than that obtained by method A.

6·Na(picrate). A solution of 53 mg (0.092 mmol) of diketone **6** in 3 mL of $CHCl_3$ was washed with 11 mL of an aqueous solution containing 45 mg (0.18 mmol) of sodium picrate and 65 mg (0.78 mmol) of Na_2CO_3. The $CHCl_3$ solution was concentrated to dryness in vacuo, and the crude product was recrystallized from 95% ethanol and dried in vacuo, yielding 58 mg (80%) of **6**·Na(picrate) as a yellow powder, mp 165−165 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.41 (s, 2 H), 7.43 (s, 1 H), 3.0−3.15 (m, 12 H), 2.8−2.9 (m, 4 H), 2.75 (m, 4 H), 2.28 (m, 4 H), 1.45−1.60 (m, 8 H), 1.03 (t, J = 7 Hz, 6 H). IR (KBr) 3090 (w), 3070 (w), 3020 (w), 2940 (s), 2920 (sh), 2860 (s), 2840 (sh), 1690 (s), 1625 (s), 1600 (sh), 1555 (s), 1480 (m), 1450 (w), 1425 (m), 1400 (w), 1390 (w), 1350 (s), 1325 (s), 1295 (s), 1280 (s), 1250 (s), 1230 (sh), 1175 (m), 1150 (m), 1065 (m), 930 (m), 915 (m), 890 (m), 780 (s), 740 (m), 720 (m), 710 (m), 700 (m), 680 (m), 540 (m). Anal. Calcd for $C_{41}H_{41}N_6O_9Na$: C, 62.75; H, 5.27; N, 10.71. Found: C, 62.47; H, 5.35; N, 10.69.

6·K(picrate). A solution of 52 mg (0.092 mmol) of diketone **6** in 3 mL of $CHCl_3$ was washed with 15 mL of an aqueous solution containing 40 mg (0.15 mmol) of potassium picrate and 42 mg (0.30 mmol) of K_2CO_3. The $CHCl_3$ solution was concentrated to dryness in vacuo, and the crude product was recrystallized from benzene/95% ethanol (2:1, v/v). The resulting fine, yellow needles were washed with benzene and dried in vacuo at room temperature for 12 h, yielding 59 mg (77%) of **6**·K(picrate), mp 189−190 °C. The 0.33 equiv of benzene contained in the crystals could not be removed by further drying at room temperature. ^{1}H NMR (300 MHz $CDCl_3$) δ 8.46 (s, 2 H), 7.44 (s, 1 H), 7.36 (s, 2 H), 2.9−3.1 (m, 12 H), 2.82 (t, J = 6 Hz, 4 H), 2.73 (m, 4 H), 2.25 (m, 4 H), 1.45−1.60 (m, 8 H), 1.02 (t, J = 7 Hz, 6 H). IR (KBr) 3080 (w), 3020 (w), 2940 (s), 2920 (s), 2860 (s), 1690 (s), 1630 (s), 1600 (m), 1550 (s), 1505 (m), 1485 (m), 1470 (m), 1450 (w), 1430 (m), 1420 (sh), 1405 (w), 1350 (m), 1320 (s), 1290 (m), 1250 (s), 1225 (m), 1210 (sh), 1180 (sh), 1170 (m), 1150 (m), 1135 (sh), 1060 (m), 900 (m), 890 (sh), 785 (m), 740 (m), 700 (m), 665 (m). Anal. Calcd for $C_{41}H_{41}N_6O_9K \cdot 1/3C_6H_6$: C, 62.46; H, 5.24; N, 10.16. Found: C, 62.57; H, 5.34; N, 9.95.

(6)$_2$Ca(CF$_3$SO$_3$)$_2$. Dibenzylidene derivative **26** (4.9 g, 7.1 mmol) was ozonized according to method A for preparation of diketone **6**. After the solvents were removed in vacuo at ca. 30 °C, the residue was dissolved in ether and the resulting solution was allowed to stand for several hours at room temperature. Fine white needles of diketone **6** (1.37 g, 34%) were collected by filtration and washed with acetone. The combined filtrates were extracted with 1 M aqueous HCl (2 × 50 mL). The combined aqueous layers were made basic with 2 M aqueous LiOH and extracted with $CHCl_3$ (50 mL). The $CHCl_3$ extract was washed with H_2O (100 mL) and concentrated by rotary evaporation. A solution of resulting glassy residue, 1 g (3.0 mmol) of calcium trifluoromethanesulfonate and ca. 5 mL of acetone was evaporated to dryness, and then the residue was chromatographed using 100 g of neutral alumina (Act. II), eluting with CH_2Cl_2/2-propanol/triethylamine (44:5:1, v/v/v). The resulting greenish-brown product was dissolved in 15 mL of CH_2Cl_2, and 45 mL of ethyl acetate was added. After several hours the crystallized product was filtered, washed with ethyl acetate/CH_2Cl_2 (3:1, v/v), and dried in air to yield 1.66 g (33%) of complex (**6**)$_2$Ca(OTf)$_2$ as pale yellow-green plates, mp 275−285 °C dec. An analytical sample was obtained by adding ethyl acetate to a solution of the product in CH_2Cl_2, drying for 4 h at room temperature in vacuo, yielding pale yellow plates, mp 275−285 °C dec. ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.80 (s, 1 H), 3.26 (s, 8 H), 2.80−2.95 (m, 8 H), 2.13 (t, J = 6 Hz, 4 H), 1.72 (m, 4 H), 1.4−1.6 (m, 8 H), 1.01 (t, J = 7 Hz, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 199.7, 152.3, 150.0, 147.6, 144.2, 140.5, 137.3, 136.9, 135.8, 37.3, 31.0, 28.3, 26.1, 25.1, 24.0, 23.0, 21.9, 13.8. IR (KBr) 3500 (w, br), 2950 (s), 2870 (s), 1740 (m), 1680 (s), 1570 (s), 1460 (sh), 1440 (s), 1360 (sh), 1260 (s, br), 1180 (m), 1140 (s), 1020 (s), 1000 (sh), 900 (w), 720 (w). Anal. Calcd for $C_{36}H_{39}N_3O_5SF_3Ca_{0.5}$: C, 61.52; H, 5.59; N, 5.98. Found: C, 61.49; H, 5.54; N, 5.91.

2,6-Bis[3-(dimethylamino)propenoyl]pyridine (36). A mixture of 1.5 g (9.2 mmol) of 2,6-diacetylpyridine and 10 mL of *tert*-butoxybis(dimethylamino)methane was heated under N_2 at 85 °C for 15 min and then cooled to room temperature. Ether (10 mL) was added, and the resulting yellow-orange solid was collected by vacuum filtration, washed with cold ether (2 × 15 mL), and dried in vacuo to afford 2.2 g (89%) of **36** as a pale yellow solid, mp 232−233 °C (lit.[45] 222−230 °C). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.22 (d, J = 7.5 Hz, 2 H), 7.92 (d, J = 12 Hz, 2 H), 7.89 (t, J = 7.5 Hz, 1 H), 6.61 (d, J = 12 Hz, 2 H), 3.18 (s, 6 H), 2.99 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$)

δ 186.5, 154.4, 149.2, 137.2, 123.4, 91.2, 44.9, 36.9. MS (FAB) *m*/*z* (rel int) 273 (100, M^+).

2,6-Bis(5,6,7,8-tetrahydroquinol-2-yl)pyridine (37). A solution of 3.6 g (53 mmol) of potassium *tert*-butoxide, 70 mL of THF and 2.0 mL (1.9 g, 19 mmol) of cyclohexanone was stirred for 1 min at room temperature. Bis(enaminone) **36** (0.30 g, 1.1 mmol) was added in one portion, and the resulting mixture was stirred for 10 h. The reaction mixture was acidified with acetic acid (25 mL), and the THF was removed by rotary evaporation. Ammonium acetate (0.80 g, 10.3 mmol) was added, and the resulting mixture was heated at 110 °C for 1 h. Volatile materials were removed in vacuo, and a solution of the resulting residue in methylene chloride (40 mL) was washed with water (3 × 50 mL). The organic layer was concentrated to dryness by rotary evaporation, and a solution of the oily residue in a few milliliters of CH_2Cl_2 was filtered through neutral alumina, eluting with CH_2Cl_2/2-propanol (20:1, v/v), to yield 0.16 g, 42% of terpyridine **37** as a yellow solid, mp 89−90 °C. ^{1}H NMR (300 MHz, $CDCl_3$) 8.37 (d, J = 8 Hz, 2 H), 8.31 (d, J = 8 Hz, 2 H), 7.85 (t, J = 8 Hz, 1 H), 7.49 (d, J = 8 Hz, 2 H), 3.01 (t, J = 6 Hz, 4 H), 2.83 (t, J = 6 Hz, 4 H), 1.79−1.98 (m, 8 H). ^{13}C NMR (75 MHz, $CDCl_3$) 156.6, 155.7, 153.6, 137.4, 137.3, 132.3, 120.2, 118.4, 32.8, 28.7, 23.2, 22.8. MS (FAB) *m*/*z* (rel int) 341 (100, M^+). Anal. Calcd for $C_{23}H_{23}N_3$: C, 80.90; H, 6.79; N, 12.30. Found: C, 80.66; H, 6.71; N, 12.11.

Stability Constants of Alkali Metal Picrate Complexes. The $H_2O/CHCl_3$ extraction experiments were carried out at 21−24 °C exactly as described previously.[46] Stability constants were calculated with absorbances measured for both phases in the case of host **6** and for the aqueous phase only in the case of host **20**. Values given in Table 1 are averages of several determinations and errors were estimated to be ±0.2−0.4 log K_s units.

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Supporting Information Available: Proton NMR data complete with peak assignments (3 pages). This material is contained in libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.

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