SYNTHESIS AND CHARACTERIZATION OF DIBENZO-18-CROWN-6 ETHERS WITH APPENDED SCHIFF BASES

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Abstract: New derivatives of dibenzo-18-crown-6 ether with two appended N_2O_2 tetradentate Schiff bases were prepared by a multistep procedure which involved the preparation of tetranitro derivative of dibenzo-18-crown-6 in acetic media, their reduction by direct hydrogenation to the tetraamino derivative and finally Schiff condensation with salicylaldehyde and *o*-vanillin in dry methanol:acetonitrile.

INTRODUCTION

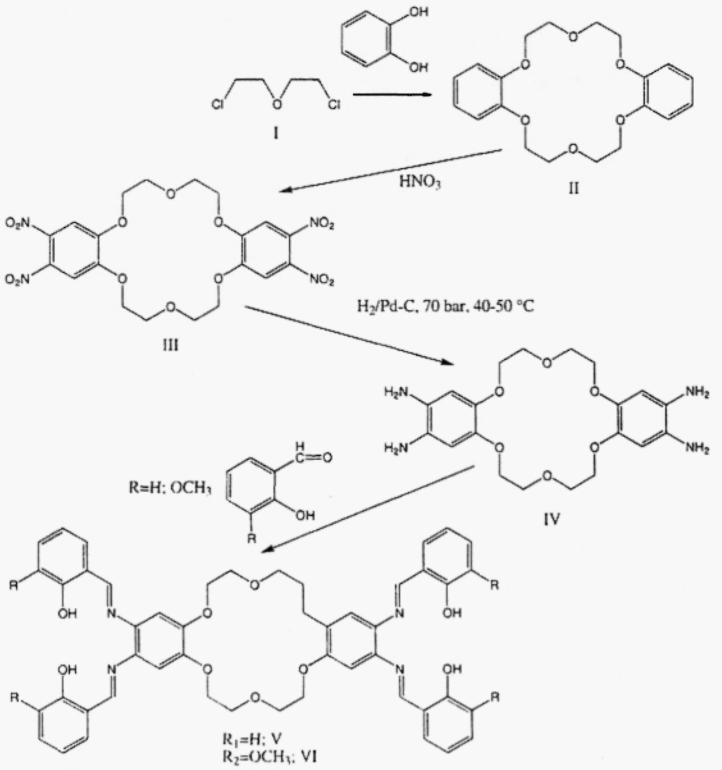
Since the work of Pedersen (1,2) there has been an enormous interest in the chemistry of crown ethers, because of their biological, medical, and chemical importance (2-8). Most of the work has concentrated on the design of selective receptors for alkaline and alkaline-earth cations, and on ways to control the crown ethers selectivity towards such species. More recently, a promising extension of this work has been the synthesis of modified crown ethers with appended functions, which are able to bind transition metals, and thus provide a way to modulate binding properties of crown ethers (5-8). Some examples are described in the literature, including crown ether-metalocene systems, diimine- and terpyridine-crown ethers, and polydentate Schiff base-crown ether systems (5-8). Upon coordination of transition metals to the polyamine or to the Schiff base ligands, some of these systems, in which the transition metal centres are close to the crown ether moiety, can act as photochemical or redox-responsive macrocycles, and ultimately can be used as molecular sensor devices for alkaline and alkaline-earth cations.

We have been interested in the synthesis of Schiff base systems (9,10), and a possible extension of this work is to prepare polyfunctional systems in which the crown ether moiety carries appended polydentate Schiff bases, as these bifunctional compounds are able to coordinate transition metals in the Schiff base moiety and alkaline and alkaline-earth cations in the crown-ether. In this work we report the synthesis of dibenzo-18-crown-6 ethers with two appended Schiff bases, which can act as N_2O_2 tetradentate ligands for two transition metal complexes. The nickel and copper complexes of these bifunctional ligands, to be published elsewhere, can be used as sensors for alkaline, alkaline-earth and lanthanides ions, by monitoring the electronic and redox properties of the transition metal ions.

RESULTS AND DISCUSSION

The new dibenzo-18-crown-6 ethers with appended Schiff bases were prepared by a multistep procedure as depicted in Scheme 1. The dibenzo-18-crown-6 ether **II** was prepared by the method of Pedersen (1,2), which involves condensation of cathecol with 1,5-dichloro-3-oxopentane **I**. Compound **II** was then converted to the tetranitro derivative **III**, by nitration of **II** in acetic acid followed by 16 hr reflux, using a procedure from literature (11,12). Reduction of **III** to the tetraamine derivative with hydrazine did not work, although such a reduction has been reported for *cis*-4,4′-dinitrodibenzo-18-crown-6 (13). However, this air-sensitive derivative **IV** could only be obtained by direct hydrogenation in methoxyethanol using a Pd-C catalyst. The final products **V**, **VI** were obtained by Schiff condensation of **IV** with the corresponding aldehyde: salicylaldehyde or *o*-vanillin. Extreme care was taken to dry the solvents, as the tetraamine is very water-sensitive.

The IR spectra of dibenzo-18-crown-6 ethers with appended Schiff bases show the C=N bond stretching vibration, a fingerprint for Schiff condensation, at 1614 (**V**) and 1612 (**VI**) cm^{-1}. These values are similar to those of N_2O_2 tetradentate Schiff bases derived from salicylaldehyde or *o*-vanillin and 1,2-phenylenediamine (H_2saloph; v(CN)=1614 cm^{-1}) (14) and with that of the similar benzo-15-crown-5 ether with appended *saloph* (v(C=N) = 1610 cm^{-1}) (15). Moreover, the characteristic absorptions of aromatic and aliphatic ether groups of the crown ether moiety occur at typical values for crown-ethers: v(Ar–O–C) = 1276 (**V**) and 1254 (**VI**) cm^{-1} and v(Ar–O–C)= 1150-1120 (**V**) and 1180-1130 (**VI**) cm^{-1} (1,2,15).



Scheme 1

Electronic spectra of dibenzo-18-crown-6 ethers with appended Schiff bases were recorded in *N,N'*-dimethylformamide, as it has proved to be the solvent of choice for the corresponding transition metal complexes. However, this solvent is not transparent for wavelengths below 310 nm, and thus its use prevents the observation of the electronic bands from the crown ether moiety, which in methanol are observed usually in the range λ_{max}= 220-280 nm (1,2,16). The electronic spectra of **V** and **VI** exhibit a strong asymmetric band at λ_{max}=364 nm (**V**) and 343 nm (**VI**), and which has two shoulders in the low-energy region; these transitions are assigned to n-π^* transition of C=N and to π-π^* transitions of the phenyl rings in the aldehyde moiety (15).

EXPERIMENTAL

All commercially available reagents were used as received. Methanol and acetonitrile used in the preparation of **V** and **VI** were dried by standard procedures, immediately prior to use (17).

Elemental analysis were performed at "Departamento de Química, Universidade de Aveiro", (Portugal), and FAB mass spectra at "Facultad de Química, Universidad de Santiago de Compostela" (Spain), using NBA (3-nitrobenzylalcohol) as matrix. ^{1}H NMR spectra were recorded on a Bruker AC 200 at 200 MHz (298K). Chemical shifts are reported in ppm referred to TMS, used as internal standard. IR spectra in the 400-4000 cm^{-1} region were recorded on a Biorad FTS 155, using KBr pellets. UV/Vis spectra were recorded in the 600-300 nm range on a Unicam UV-2, at room temperature, using quartz cell with 1cm optical path. The reported melting points are uncorrected.

Synthesis

1,5-Dichloro-3-oxapentane **I** and *dibenzo-18-crown-6* **II** were prepared by the method of Pedersen (1). **I**: light-yellow liquid; yield 90 %; ^{1}H NMR ($CDCl_3$) δ 3.82-3.76 (m; 4H;–CH_2), 3.67-3.62 (m; 4H; –CH_2). **II**: white solid; yield 31 %; mp 158-162 °C (literature 162-164 °C); ^{1}H NMR ($CDCl_3$) δ 7.00-6.87 (m; 8H, aromatic H), 4.12-4.08 (m; 8H; –CH_2), 3.90-3.85 (m; 8H; –CH_2). Anal. calcd for $C_{20}H_{24}$: C, 66.65; H, 6.71. Found: C, 66.68; H, 6.71.

Bis(3,4-dinitro)dibenzo-18-crown-6 **III**: HNO_3 65% (68 mL) was added dropwise with stirring over 1h to a solution of **II** (8.84 g; 0.025 mol) in acetic acid (300 mL). After the addition was complete, the mixture was heated under reflux for 16 h with stirring. Upon cooling the mixture, the yellow solid was filtered, washed with water and dried at 100 °C. Yield 5.19 g (38%); mp 226-230°C. ^{1}H NMR (d_6-Me_2SO) δ 7.78 (s; 4H; aromatic H), 4.43-4.23 (m; 8H; –CH_2), 3.97-3.78 (m; 8H; –CH_2). IR (KBr) (ν/cm^{-1}): 3124, 3068, 2930, 2883, 1636, 1588, 1534, 1446, 1375, 1357, 1338, 1292, 1234, 1146, 1092, 1064, 1046, 964, 910, 878, 810, 798, 750, 667. Anal. calcd for $C_{20}H_{20}O_8N_4$: C, 44.45; H, 3.73; N, 10.37. Found: C, 44.46; H, 3.74; N, 10.39.

Bis(3,4-diamino)dibenzo-18-crown-6 **IV**: a mixture of **III** (1.0g; 2.25 mmol), Pd-C (5 %; Aldrich) (0.23g) and 2-methoxyethanol (50 mL) was hydrogenated at 40-50 °C and 70 bar for 20 h. The reaction mixture was passed through a Celite column and washed with methanol/methoxyethanol (1:1) (50 mL). The dark green solid was collected by filtration under reduced pressure, washed with diethyl ether and stored under an inert atmosphere; yield 0.71g (97 %). ^{1}H NMR (d_4-MeOH) δ 6.46 (s; 4H; aromatic H), 3.92 (s; 4H; –CH_2), 3.79 (s; 4H; –CH_2), 3.59-3.57 (m; 8H; –CH_2), 3.48-3.45 (m; 8H; –NH_2).

Dibenzo-18-crown-6-bis(H_2salophen) **V**: all the procedure was performed under an argon atmosphere. To a warm solution of **IV** (1.65 g; 3,9 mmol) in methanol/acetonitrile (2:1) was added a solution of salicylaldehyde (1.92 g; 16.0 mmol) in methanol. The mixture was refluxed for 2 h. The resulting orange solid was filtered under reduce pressure and washed with ethanol; yield 1.44 g (44%). ^1H NMR (d_6-Me_2SO) δ 13.18 (s; 4H; -OH), 8.96 (s; 4H; =CH), 7.64-7.60 (d: 4H; aromatic H), 7.42-7.34 (m; 4H; aromatic H) , 7.17 (s; 4H; aromatic H), 6.96-6.92 (m; 8H; aromatic H), 4.23-4.05 (m; 8H; -CH_2), 3.89 (s; 8H -CH_2). IR(KBr) (ν/cm^{-1}): 2926, 2874, 1614, 1580, 1511, 1493, 1455, 1410, 1383, 1364, 1315, 1276, 1263, 1234, 1183, 1150, 1121, 1054, .1037, 981, 958, 944, 908, 852, 770, 757. UV/Vis λ_{max} (dmf)/nm (ε/dm^{3}mol^{-1}cm^{-1}) 402 sh (28750), 371 sh (37110), 343 (40126). *m/z* $[M+H]^+$ 837.5 (43.6).

Dibenzo-18-crown-6-bis(H_2-3-MeOsalophen) **VI**: the synthesis is identical to that of **V**, except that *o*-vanillin was used instead of salicylaldehyde. Orange solid; yield 1.64 g (42%). ^1H NMR (d_6-Me_2SO) δ 13.26 (s; 4H; -OH), 8.95 (s; 4H; =CH), 7.24-6.90 (m; 16H; aromatic H), 4.24-3.81 (m; 28H; -CH_2, -OCH_3). IR(KBr) (ν/cm^{-1}): 2931, 2881, 2835, 1612, 1577, 1545, 1510, 1464, 1437, 1407, 1254, 1208, 1187, 1130, 1096, 1077, 1054, 970, 936, 839, 780, 733, 668. UV/Vis λ_{max} (dmf)/nm (ε/dm^{3}mol^{-1}cm^{-1}) 404 sh (27340), 370 sh (40510) 364 (42210). *m/z* $[M+H]^+$ 957.5 (81.3).

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