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Two novel calix[4]cryptands were synthesized from 1,3-alternate calix[4]bis-azacrown. "Mappemonde II" consists of one 1,3-calix[4]bis-azacrown wrapped by a benzo-crown ether loop. "Mill II" is composed of two 1,3-calix[4]bis-azacrowns linked by two benzo-crown ether strands.

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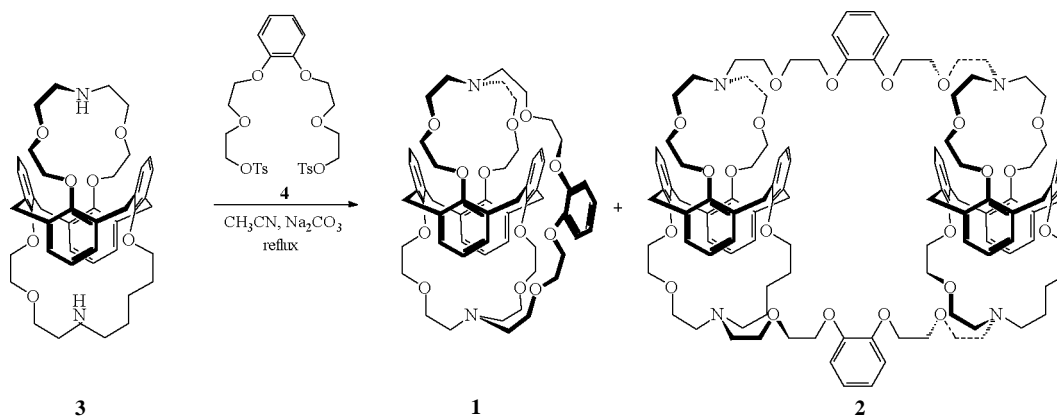
One of the consequences of the research dealing with supramolecular and assembled architectures is the development of synthetic strategies for constructing artificial systems with a precise disposition of atoms and functional groups to obtain a desired behaviour [1]. Molecular manufacturing [2] and molecular engineering [3] are approaches to the development of general capabilities for molecular manipulation to produce new organic and biological materials manufactured 'atom by atom' [4] at the molecular level. For examples such terms as 'Molecular-size Tinkertoy construction' [5], 'Molecular Lego' [2], and 'Molecular Meccano' [6], with an obvious reference to children's construction games, have been used in the literature to characterize this branch of organic chemistry. For instance, a triptycene unit has been inserted in a crown ether to create a triptycencrown ether performing rope-skipping. The triptycene rotation was slowed-down by coordination of thallium by the crown ether loop [7]. Bistriptycencrown ethers in which two triptycene gears are connected by two polyoxyethylene links at the axles showed correlated rotation [8]. Calixarenes have been shown to be useful building blocks to synthesize molecular

systems in many branches of supramolecular and related chemistry [9]. 1,3-calix[4]bis-crowns have been used to design and synthesize molecular *mappemondes* [10] and a molecular *mill* [11]. It has been evidenced by ^1H nmr that the molecular spheres are acting as *rotors* in such molecular objects. The stopping of the rotation of the calix[4]bis-crown units was realized by complexation of several ammonium cations within the molecular structures [10,11].

With reference to these previous works [10,11] we have designed related molecular structures **1** and **2** corresponding to the molecular "mappemondes" and "mill" in which the 1,3-calix[4]bis-crown has been replaced by the already published 1,3-calix[4]bis-(aza)crown **3** [12]. The two nitrogen atoms in the crown loops were used to attach the polyether links.

As depicted in Scheme 1, the synthesis of **1** and **2** started with the condensation of 1,3-calix[4]bis-azacrown **3** with 1 equivalent of benzoheptaethylene glycol ditosylate (**4**) [13] in acetonitrile by using excess of Na_2CO_3 as base under reflux for 24 hours. Purification by column chromatography on alumina with a 9/1 dichloromethane/methanol as eluent gave **1** and **2** as white solids.

Scheme 1



Synthesis of calix[4]cryptand **1** and **2**

^1H nmr spectra of **1** and **2** were quite similar presenting the same integration ratio between aromatic protons and glycolic protons. However, they were different in the resolution of the peaks in the glycolic region. The glycolic signals of **1** were overlapping while the one of **2** were not. That the calix[4]arenes units were in the 1,3-alternate conformation was shown by the appearance of singlet at 3.89 ppm for **1** and 3.82 ppm for **2** matching the value of 3.88 ppm in **3** [12]. For the mass spectra, one contained a peak at m/z 1025.5 corresponding to calix[4]cryptand mappemonde (**1**) + H + 2H₂O and the other one had a peak at m/z 2016.5 indicating calix[4]cryptand mill (**2**) + K⁺. Compound **1** was obtained in 28 % yield while ligand **2** was afforded only in 9 % yield. Interestingly the condensation of calix[4]bis-crown with naphtho-crown ether in high dilution condition afforded the "1+1" product in 5 % yield lower than the 20 % yield of "2+2" product. It was explained by steric hindrance of the "1+1" product [11]. In our case, the high dilution can overcome this effect. Moreover, as the substitution sites (amino groups) did not point to the poles of 1,3-calix[4]bis-azacrown which can be observed in the crystal structure of picoyl-armed 1,3-alternate calix[4]arene azacrown ether [14], the benzo-crown unit could bridge 1,3-calix[4]bis-azacrown in "1+1" fashion easier than "2+2" mode.

Concerning the molecular behavior of compounds **1** and **2**, the ^1H nmr spectra revealed that the spectrum of mappemonde **1** had less resolution than that of mill **2**. This probably comes from the fact that benzo-crown unit crossed over the 1,3-alternate calix[4]bis-azacrown framework of **1** while they just linked two calix[4]arene units together in compound **2**. This allowed us to conclude that the mappemonde **1** shows no rotation around the 1,3-alternate calix[4]arene axis as found in 1,3-alternate calix[4]bis-crown "Mappemonde" [10]. This is illustrated by the "asymmetrical" signal of NCH₂- protons which present a multiplet at 2.77-2.68 ppm. This may stem from the fact that the linkage points are nitrogen atoms that possess pyramidal geometry. And one can also assume that the glycolic chain of the benzo-crown ether loop gets in lock with the glycolic chains of the azacrown of 1,3-alternate calix[4]bis-azacrown framework as we can see in the similar protocol [14].

Although inversion of the nitrogen atom can occur easily [15], rotation of compound **1** was not observed. In the same manner, molecular mill **2** can also not rotate around the 1,3-alternate calix[4]arene axis as mentioned in 1,3-alternate calix[4]bis-crown "Mill" [11]. This was shown by the multiplet of "asymmetric" protons of the NCH₂-moieties. Even though, the two calix[4]arene units of calix[4]cryptand-Mill (**2**) were separated by benzo-crown spacers, the rotation can not occur. This may be because the geometry of the nitrogen atoms did not facilitate the

rotation. Besides this, it led to a twist of the two calix[4]arene units and brought them close to each other.

Future studies are directed to complexation behavior of these new concave structures by usual means (^1H nmr and UV-visible spectrophotometries in order to develop this new class of calix[4]cryptands.

EXPERIMENTAL

^1H and ^{13}C nmr spectra were recorded on a Bruker ACF 200 MHz spectrometer. Tetramethylsilane was used as an internal standard. The ms spectra were obtained on a ZAB HF VG-Analytic mass spectrometer using the fast atom bombardment (FAB) technique. All solvents were purified by standard procedures. Starting materials were used without further purification. 1,3-Calix[4]bis-azacrown (**3**) [12] and benzoheptaethylene glycol ditosylate (**4**) [13] were prepared according to the literature procedures.

Mappemonde **1** and Mill **2**; General Procedure.

1,3-Alternate calix[4]bis-azacrown (**3**) (0.074 g., 0.1 mmole), 0.106 g. (1.0 mmole) of Na₂CO₃ and 80 mL of acetonitrile was stirred. Then, a solution of 0.059 g. (0.1 mmole) of benzoheptaethylene glycol ditosylate (**4**) in 20 mL of acetonitrile was added dropwise. After 24 hours of reflux, the reaction mixture was cooled to room temperature and evaporated to dryness under reduced pressure. The obtained residue was dissolved in 50 mL of CH₂Cl₂ and 2x50 mL of H₂O were added to the extract. The organic layer was separated, dried over Na₂SO₄ anhydrous, filtered and evaporated to dryness. The residue was chromatographed on alumina column by using MeOH/CH₂Cl₂: 10/90 as eluent.

Compound **1** was isolated as a white solid in a 28 % yield; ^1H nmr (CDCl₃): δ 7.13-7.05 (m, 8 H, *p*- and *m*-ArH_{calix}); 6.92-6.81 (m, 8 H, *m*-ArH_{calix} and ArH_{benzo}); 4.17 (broad s, 6 H, ArOCH₂); 3.91-3.56 (m, 12 H, ArOCH₂ and OCH₂); 3.89 (s, 8 H, ArCH₂Ar); 3.50 (t, 6 H, *J* = 5.0 Hz, OCH₂); 3.33 (t, 6 H, *J* = 5.0 Hz, OCH₂); 3.15 (t, 6 H, *J* = 5.0 Hz, OCH₂); 2.77-2.68 (m, 12 H, NCH₂); ms (FAB⁺, NAB): m/z = 1025.5 ((M+H+2H₂O)⁺, calc, 1025.5).

Compound **2** was isolated as a white solid in a 9 % yield; ^1H nmr (CDCl₃): δ 7.09-7.05 (m, 12 H, *p*- and *m*-ArH_{calix}); 6.91-6.81 (m, 20 H, *m*-ArH_{calix} and ArH_{benzo}); 4.17 (t, 12 H, *J* = 5.0 Hz, ArOCH₂); 3.91-3.81 (m, 12 H, ArOCH₂); 3.82 (s, 16 H, ArCH₂Ar); 3.65 (t, 12 H, *J* = 5.0 Hz, OCH₂); 3.50 (t, 12 H, *J* = 5.0 Hz, OCH₂); 3.33 (t, 12 H, *J* = 5.0 Hz, OCH₂); 3.15 (t, 12 H, *J* = 5.0 Hz, OCH₂); 2.77-2.68 (m, 24 H, NCH₂); ms (FAB⁺, NAB): m/z = 2016.5 (M + K⁺, calc, 2016.0).

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