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Communications

Synthesis and Structure of Tetrahomodioxa *p*-Phenylcalix[4](aza)biscrowns

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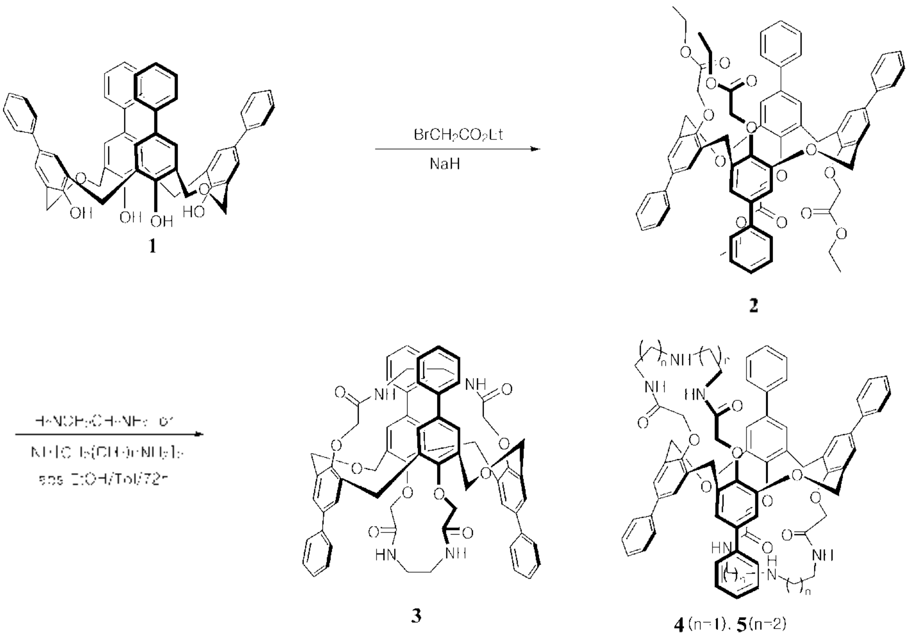
Calixarenes have been intense interest as complexation hosts for ions and molecules.[1-3] Tetrahomodioxacalix[4]-arenes which contain two extra oxygen atoms in the macrocyclic ring, however, have been rarely studied due to their synthetic difficulty.[4-8] Previously, we reported that C-1,2-alternate[9] *N,N*-diethyltetrahomodioxacalix[4]arene tetra-amide showed Pb^{2+} ion selectivity.[10] In the case of *mono*alkyl amide, however, the conformation changes to 1,3-alternate conformation because of the strong hydrogen bonding, reflecting weak extractability for metal cations.[9]

Calix[4]crown ethers in which the proper-sized crown rings are incorporated into the calix[4]arene framework have been also attracted as a specific metal-selective extractant.[11] 1,3-Alternate calix-*bis*-crowns have particularly interesting molecular features including the cation-π interaction as well as the electrostatic interaction in cation complexation.[12] The family of calix[4](aza)crowns refer to molecules combining calix[4]arene elements and aza-crown units in their frame-work. They are constructed with aza-ethylene chains attached to the phenolic oxygen atoms of the calix via acetamido functions, which may serve as linking functions and also as chelating groups. The first 1,3-calix[4](aza)crowns were



Scheme 1

prepared by reaction of either calix dimethyl ester or calix diacid chloride with the appropriate diamine, NH_2-R-NH_2, and were shown to complex divalent and trivalent metal cations using FAB-mass spectrometry.[13] After pioneering study of Rheinhoudt, Bitter and Vicens research groups reported the synthesis and complexation studies of *p-tert*-butylcalix[4]-(aza)crown derivatives.[14] However, crown or azacrown derivatives of homooxacalix[4]arene were not reported yet.

In a continuation of the homooxacalixarene, we synthesized tetrahomodioxa-*p*-phenylcalix[4](aza)biscrowns of which conformations are 1,3- and C-1,2-alternate. The synthetic route for homooxacalix[4](aza)biscrowns is depicted in Scheme. Reaction of **2**[10] having a C-1,2 alternate conformation with ethylenediamine and dialkylenetriamine in absolute ethanol and toluene gave **3**, **4** and **5**, respectively. Judging from ^{1}H and ^{13}C NMR spectroscopy, **3** was found in the 1,3-alternate conformation and **4** and **5** in the C-1,2-alternate conformation, respectively.

In the ^{1}H NMR spectrum of **3**,[15] the dimethylenoxy protons of the ArCH_2OCH_2Ar bridge showed AB doublets at 4.28 and 4.13 ($\Delta\upsilon = 60$ Hz) with a *geminal* coupling constant of 14.1 Hz. In addition, a singlet peak for the methylene protons of ArCH_2Ar appeared at 4.06. The ^{13}C NMR spectrum showed one peak at 68.93 ppm for the $\mathrm{ArCH_2O}$ of bridge methyleneoxy carbons and one peak at 37.85 ppm for the $\mathrm{ArCH_2Ar}$ bridge carbons implying that two adjacent benzene rings are in an *anti* orientation. These NMR data confirms that **3** is in 1,3-alternate conformation.

For **4**,[16] in the ^{1}H NMR spectrum, the dimethylenoxy protons of the ArCH_2OCH_2Ar bridge showed AB doublets at 4.38 and 3.80 ($\Delta\upsilon = 232$ Hz) with a *geminal* coupling constant of 14.0 Hz. In addition, a doublet peaks for the methylene protons of ArCH_2Ar appeared at 4.52 and 3.58 ($\Delta\upsilon = 376$ Hz) with a *geminal* coupling constant of 13.2 Hz. The ^{13}C NMR spectrum showed one peak at 73.59 ppm for the $\mathrm{ArCH_2O}$ of bridge methyleneoxy carbons and one peak at 30.17 ppm for the $\mathrm{ArCH_2Ar}$ bridge carbons implying that two adjacent benzene rings are in an *syn* orientation. So, it is in the C-1,2-alternate conformation. The NMR spectral data of **5**[17] were similar with the those of compound **4**, the protons of the ArCH_2OCH_2Ar and ArCH_2Ar bridge showed AB doublets. The ^{13}C NMR spectrum showed one peak at 73.66 ppm for the $\mathrm{ArCH_2O}$ bridge methyleneoxy carbons and one peak at 31.42 ppm for the $\mathrm{ArCH_2Ar}$ bridge carbons which is also indicating that two adjacent benzene rings are in a *syn* orientation (C-1,2-alternate conformation).

Further works on complexation experiments with **3**, **4** and **5** as ligand are in progress.

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15. **3**, 63%; mp 282 °C (decompose); ^{1}H NMR ($CDCl_3$) δ 7.41-7.34 (m, 24, Ar*H*), 7.29-7.25 (m, 4, Ar*H*), 5.89 (br. d, 4, N*H*, J = 5.5 Hz), 4.81 (d, 4, OCH_2CO, J = 12.9 Hz), 4.33 (d, 4, OCH_2CO, J = 12.9 Hz), 4.28 (d, 4, ArCH_2O, J = 14.1 Hz), 4.13 (d, 4, ArCH_2O, J = 14.1 Hz), 4.06 (s, 4, ArCH_2Ar), 3.18 (br. q, 4, NCH_2, J = 6.3 Hz), 2.30 (br. q, 4, NCH_2, J = 6.3 Hz). ^{13}C NMR ($CDCl_3$) δ 167.89 (C=O), 152.57, 139.61, 138.92, 133.55, 130.82, 129.25, 128.97, 127.98, 127.15, 126.48 (Ar), 69.18 ($\mathrm{OCH_2CO}$), 68.93 ($\mathrm{ArCH_2O}$), 39.05 ($\mathrm{NCH_2}$), 37.85 ($\mathrm{ArCH_2Ar}$). Anal. Calcd. For $C_{66}H_{60}O_{10}N_4$: C, 74.14; H, 5.66. Found: C, 74.41; H, 5.48.
16. **4**, 55%; mp 290 °C (decompose); ^{1}H NMR ($CDCl_3$) δ 7.60 (d, 8, Ar*H*, J = 7.7 Hz), 7.53 (br. s, 8, Ar*H*), 7.47 (t, 8, Ar*H*, J = 7.7 Hz), 7.38 (t, 4, Ar*H*, J = 7.4 Hz), 6.84 (br, 6, N*H*), 4.94 (d, 4, OCH_2CO, J = 11.0 Hz), 4.52 (d, 2, ArCH_2Ar, J = 13.2 Hz), 4.38 (d, 4, ArCH_2O, J = 14.0 Hz), 4.23 (d, 4, OCH_2CO, J = 11.0 Hz), 3.80 (d, 4, ArCH_2O, J = 14.0 Hz), 3.58 (d, 2, ArCH_2Ar, J = 13.2 Hz), 2.90 (br. m, 4, NCH_2), 2.45 (br. m, 4, NCH_2), 2.23 (br. m, 4, NCH_2), 2.19 (br. m, 4, NCH_2). ^{13}C NMR ($CDCl_3$) δ 167.51 (C=O), 154.30, 139.62, 138.03, 134.91, 130.27, 129.79, 129.64, 128.96, 127.66, 127.05 (Ar), 73.59 ($\mathrm{ArCH_2O}$), 67.77 ($\mathrm{OCH_2CO}$), 45.94, 37.75 ($\mathrm{NCH_2}$), 30.17 ($\mathrm{ArCH_2Ar}$). Anal. Calcd. For $C_{76}H_{70}O_{10}N_6$: C, 72.77; H, 6.11. Found: C, 72.51; H, 6.08.
17. **5**, 46%; mp 274 °C (decompose); ^{1}H NMR ($CDCl_3$) δ 7.51-7.29 (m, 34, Ar*H*, & N*H*), 4.88 (d, 2, ArCH_2Ar, J = 14.6 Hz), 4.60 (s, 8, OCH_2CO), 4.06 (br. d, 4, ArCH_2O, J = 12.0 Hz), 3.79 (d, 4, ArCH_2O, J = 12.0 Hz), 3.51 (d, 2, ArCH_2Ar, J = 14.6 Hz), 3.18 (br, 4, NCH_2), 3.07 (br, 4, NCH_2), 2.26 (br, 4, NCH_2), 2.22 (br, 4, NCH_2), 1.38 (br, 8, CH_2). ^{13}C NMR ($CDCl_3$) δ 168.27 (C=O), 154.92, 139.64, 137.58, 134.64, 130.44, 130.08, 129.18, 128.95, 127.82, 126.94 (Ar), 73.66 ($\mathrm{ArCH_2O}$), 68.10 ($\mathrm{OCH_2CO}$), 45.48, 36.12 ($\mathrm{NCH_2}$), 31.42 ($\mathrm{ArCH_2Ar}$), 28.71 ($\mathrm{CH_2}$). Anal. Calcd. For $C_{74}H_{78}O_{10}N_6$: C, 73.37; H, 6.49. Found: C, 73.11; H, 6.28.