

Synthesis and Properties of Double Calix[4]arene Derivatives Linked by Schiff-base in the Lower Rim

Hu Shan YUAN, Zhi Tang HUANG*

Institute of Chemistry, The Chinese Academy of Sciences, Beijing 100080

Abstract: 25,27-bis-(2-aminoethoxy)-*p*-tert-butylcalix[4]arene was linked to double calix[4]arene derivatives by the Schiff-base moiety in its lower rim. They behave strong ability to complex with Pb^{2+} , Cu^{2+} and Co^{2+} .

Keywords: 25,27-Bis-(2-aminoethoxy)-*p*-tert-butylcalix[4]arenes, Schiff-base, double calix[4]arene.

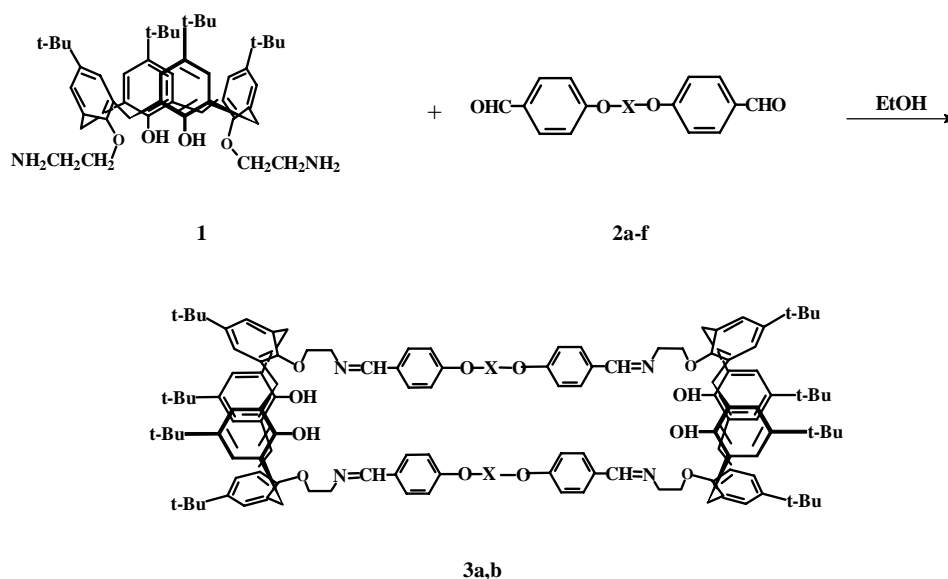
Calixarenes are regarded as the third generation of host molecules because of their inclusion ability to cations, anions and neutral molecules^{1,2}. During the past decade most efforts have been taken on the functionalization of calixarenes so that they can be applied not only as the ionophores in the extraction process^{3,4} and as sensitive materials for ion electrodes^{5,6}, but also as the enzyme mimics catalyzing the cleavage of phosphate diesters^{7,8}. In order to enable them to include and recognize larger chemical species, many approaches have been used to construct oligo-calixarenes to enlarge the cavity of the molecules⁹⁻¹⁶. This communication describes the synthesis and properties of double calix[4]arenes linked by Schiff-base.

The double calix[4]arenes were synthesized according to **Scheme 1**. Compounds **3a,b** are obtained by refluxing the mixture of **1** and **2a** or **2b** in anhydrous ethanol. The experimental results show that the length of X in the compounds **2** greatly influences the reaction. When **2a** reacts with **1**, the reaction finished within one hour. On the other hand, the reaction time of **2b** with **1** should be lengthened to 24 hours. Besides **2a** and **2b**, **2c-f** had also been put into the reaction. Unfortunately, no reaction was observed as monitored by TLC of aluminum oxide after 48 hr refluxing. Sulfuric acid was applied to catalyze the reaction, no reaction happened either.

The structures of **3a,b** are confirmed by microanalysis, IR, MS, and NMR spectra¹⁷. The ¹H NMR doublet-doublet pattern of the methylene protons between the phenol rings shows that compounds **3a** and **3b** are in cone conformation. Comparing the ¹H NMR spectra of compounds **3a** and **3b** with those of **2a,b** and **1**, it is found that all the proton signals on the calixarene skeleton shift to down field, but the proton signals on the fragments of **2a,b** shift to up field. The new ¹H NMR singlet around 8.4 ppm and the IR absorption peaks at 1643 cm^{-1} indicate the formation of carbon-nitrogen double bond of Schiff-base. The molecular weights of **3a,b** are determined by MALDI-TOF MS. The

values of m/z , 1938 for **3a** and 1966 for **3b**, clearly indicate that **3a** and **3b** are double calix[4]arene derivatives instead of mono-analogues.

Scheme 1 Synthesis of compounds **3a,b**



2a-f	2a	2b	2c	2d	2e	2f
X	(CH ₂) ₂	(CH ₂) ₃	CH ₂ CH ₂ - OCH ₂ CH ₂	CH ₂ (CH ₂ - OCH ₂) ₂ CH ₂	CH ₂ CH- (OH)CH ₂	

The complexation constants of **3a,b** with Pb^{2+} , Cu^{2+} and Co^{2+} were determined in the mixture of methanol and chloroform (methanol : chloroform: V/V= 3/2) by the UV spectrophotometry at 20°C. The procedure consists of adding increasing amount of metallic salt solution [$\text{Pb}(\text{NO}_3)_2$, CuBr_2 and CoCl_2] to the solution of the ligands. The resulting spectral changes were analyzed by the SIRK program¹⁸. The values of the corresponding stability constants (as Log K) are listed in **Table 1**. The results show that both **3a** and **3b** can strongly complex with Pb^{2+} , Cu^{2+} and Co^{2+} . The length of X in **3a,b** does not influence their complexation abilities.

Table 1 Stability Constants in the Mixture of Methanol and Chloroform at 20°C

Cations	Ionic radii (Å)	Log K	
		3a	3b
Pb^{2+}	1.18	4.6	4.8
Cu^{2+}	0.73	4.6	4.7
Co^{2+}	0.65	4.2	4.3

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17. **3a**: 100 mg compound **1** (0.135 mmol) was mixed with 36.5 mg **2a** (0.135 mmol) in 10 ml anhydrous ethanol. After the mixture was refluxed for about 1 hour, white precipitate was formed and collected by suction. After recrystallization from ethyl acetate, 80 mg sample of **3a** was obtained. Yield: 63%. mp: 202.0-203.0 °C. Anal. for C₁₂₈H₁₅₂N₄O₁₂: Calcd.: C 79.30, H 7.90, N 2.89, Found: 79.10, H 8.03, N 2.81. MS: 1938 (M⁺). IR (KBr, cm⁻¹): 3430 (OH), 1643 (C=N). ¹H NMR (CDCl₃), δ (ppm): 8.36 (s, 4H, CH=), 7.72 (d, 8H, ArH), 7.14 (s, 4H, OH), 7.02 (s, 8H, ArH), 6.83 (d, 8H, ArH), 6.74 (s, 8H, ArH), 4.33 (d, 8H), 3.27 (d, 8H), (ArCH₂Ar), 4.16-4.24 (m, 8H, OCH₂CH₂N), 4.00-4.08 (m, 16H, OCH₂CH₂N, OCH₂CH₂O), 1.29 (s, 36H, CH₃), 0.91 (s, 36H, CH₃). ¹³C NMR (CDCl₃), δ (ppm): 162.8, 160.5, 150.7, 150.0, 146.7, 141.2, 132.5, 130.0, 129.8, 127.9, 125.4, 124.9, 114.6, 96.1, 75.6, 66.2, 60.5, 33.9, 33.8, 31.73, 31.70, 31.0.
- 3b**: 100 mg compound **1** (0.135 mmol) was mixed with **2b** 38.4 mg (0.135 mmol) in 10 ml anhydrous ethanol. The mixture was refluxed overnight. After removal of the solvent under vacuum, a waxy residue was obtained. Then the residue was dissolved in a mixture of chloroform and methanol. With the slow evaporation of the solvent, the oily substance solidified. The solid was collected by suction. The needle crystal of **3b** (90 mg) could be obtained by recrystallization from ethyl acetate. Yield: 70%. mp: 238.5-240.0°C. Anal. for C₁₃₀H₁₅₆N₄O₁₂: Calcd. C 79.39, H 8.00, N 2.85, Found: C 79.05, H 7.93, N 2.54. MS: 1966 (M⁺). IR (KBr, cm⁻¹): 3380 (OH), 1643 (C=N). ¹H NMR (CDCl₃), δ (ppm): 8.39 (s, 4H,

CH=N), 7.70 (d, 8H, ArH), 7.09 (s, 4H, OH), 7.00 (s, 8H, ArH), 6.86 (d, 8H, ArH), 6.73 (s, 8H, ArH), 4.29 (d, 8H), 3.26 (d, 8H), (ArCH₂Ar), 4.20-4.28 (m, 8H, OCH₂CH₂N), 4.05-4.14 (m, 16H, OCH₂CH₂N, OCH₂CH₂CH₂O), 2.01 (quin, 4H, OCH₂CH₂CH₂O), 1.27 (s, 36H, CH₃), 0.91 (s, 36H, CH₃). ¹³C NMR (CDCl₃), δ (ppm): 163.0, 160.8, 150.7, 150.0, 146.7, 141.1, 132.5, 132.0, 130.0, 127.9, 125.4, 124.9, 114.4, 96.1, 75.6, 64.4, 60.5, 33.9, 33.8, 31.7, 31.5, 31.0, 29.1.

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