*Asian Journal of Chemistry; Vol. 25, No. 1 (2013), 515-517*

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2013.13395

# Synthesis and Crystal Structure of a Novel Hexahomotrioxacalix[3]cryptand

XUE-KAI JIANG[1], MIN DENG[1], LAN MU[1], XI ZENG[1,*], JIAN-XIN ZHANG[2] and TAKEHIKO YAMATO[3]

[1]Key Laboratory of Macrocyclic and Supramolecular Chemistry of Guizhou Province, Guizhou University, Guiyang 550025, P.R. China
[2]The Key Laboratory of Chemistry for Natural Products of Guizhou Province and Chinese Academy of Sciences; Guiyang 550002, P.R. China
[3]Department of Applied Chemistry, Faculty of Science and Engineering, Saga University, Honjo-machi 1, Saga-Shi, Saga 840-8502, Japan

*Corresponding author: E-mail: zengxi1962@163.com

(*Received*: 6 January 2012; *Accepted*: 2 August 2012) AJC-11914

A novel hexahomotrioxaacalix[3]cryptand was synthesized and its crystal structure has been determined. The crystals obtained by recrystallization from ethanol, are singal clinic, space group is C2/c, a = 19.6831(16)Å, b = 16.8180(16)Å. c = 29.267(3)Å, α = 90.00º, β = 105.222(4)º, γ = 90.00º. $^1$H NMR spectroscopy and X-ray single-crystal structure results suggested that this compound was fixed in a cone conformation.

**Key Words: Oxacalix[3]arene derivative, Synthesis, Crystal structure, Cone conformation.**

## INTRODUCTION

In past decade, calixarenes have been attracted considerable attention due to their molecular recognition properties[1]. To enhance molecular/ionic binding ability and altered selectivity more efficient compared with the parent calixarenes, calixarenes generally be modified into different conformation isomers by introduction of large bulky substituents on their phenolic oxygens, blocking interconversion by oxygen-through-the-annulus rotation[2]. For example, one of the method is to build a bridge on the lower or up rim. As a result, many tripodal calixarenecryptands such as tripodal calix[4]cryptand[3], tripodal calix[6]cryptand[4] were prepared.

Hexahomotrioxacalix[3]arene has more flexible conformation than calix[4]arene, because of the ether linkage. The presence of oxygen atom in oxacalixarenes is envisioned to adding the binding site and other specific features, such as building sophisticated ligand system. Indeed, such sophisticated ligands could be easily obtained by functionalization at the upper rim and/or lower rim, as usually done for classical calixarenes. Some examples have been given leading to an improvement of their ability to complex.

Recently, we synthesized a novel rhodamine amide-arm homotrioxacalix[3]arene, which shown excellent complexation ability for antimony and transition metal cations[5]. In order to further understanding of the relationship between the structure and molecular/ionic recognition ability of oxacalix[3]-arene derivatives, and continue our previous work, herein, we report the synthesis and crystal structure of a hexahomotri-oxacalix[3]-cryptand.

## EXPERIMENTAL

The melting points were measured by an X-5 apparatus and are uncorrected. $^1$H NMR spectra were measured with JEOL-ECX 500 MHz NMR spectrometers at room temperature using TMS as an internal standard. Crystal X-ray diffraction was conducted on a Bruker Smart ApexII CCD diffractometer. IR spectra were obtained using a Bruker Vertex 70 FT-IR spectrometer.

### Synthetic procedures:

**Preparation of compound 2a and 2b:** The *p-tert*-butylhomooxacalix[3]arene can be easily prepared by the condensation of *p-tert*-butylphenol and formaldehyde. Tricalix[3]arene (**1**) (2g, 3.44 mmol) and dry THF (100 mL) were added in round bottom flask, then added NaH (840 mg, 60 %, 21 mmol). The mixed solution was refluxed for 1 h, then added ethyl chloroacetate (2.65 g, 21 mmol), the solution was refluxed for 2 days and cooled to room temperature. Removed the THF under reduced pressure, the residue was dissolved in ethyl acetate (120 mL), washed with 10 % HCl (50 mL), water (50 mL × 2), brine (50 mL) and dried with anhydrous sodium sulphate. The filtrate was evaporated to get light yellow solid. Chromatographed over silica gel using $CH_2Cl_2$/acetone (14:1) as eluent to give a colourless solid, recrystallized from methanol to give pure white crystal, cone compound (**2a**) 1.8 g, yield 28 %. m.p. 70-72 ºC; $^1$H NMR (500 MHz, $CDCl_3$): δ (ppm) 1.09 (s, 27H, *t*-Bu), 1.34 (t, 9H, $J$ = 16 Hz, $CH_2CH_3$), 4.27 (q, 6H, $J$ = 6.8 Hz, $OCH_2CH_3$), 4.50 (s, 6H, $OCH_2CO$), 4.53 (d, 6H, $J$ = 16, $OCH_2$), 4.91 (d, 6H, $J$ = 16 Hz, $OCH_2$), 6.95 (s, 6H, ArH); IR (KBr, $\nu_{max}$, cm$^{-1}$): 1750, 1190.

The partial cone compound (**2b**) 0.28 g, yield 58 %, m.p. 146-148 ºC; $^1$H NMR (500 MHz, $CDCl_3$): δ (ppm) 1.09 (t, 3H, $CH_2CH_3$), 1.22 (t, 6H, $CH_2CH_3$), 1.25 (s, 18H, *t*-Bu), 1.33 (s, 9H, *t*-Bu), 3.22 (s, 2H, $OCH_2CO$), 4.22 (d, 2H, $OCH_2CO$), 4.51 (d, 2H, $OCH_2CO$), 3.79 (q, 2H, $OCH_2CH_3$), 4.10 (q, 4H, $OCH_2CH_3$), 4.17 (d, 2H, $OCH_2Ar$), 4.23 (d, 2H, $OCH_2Ar$), 4.34 (d, 2H, $OCH_2Ar$), 4.63 (d, 2H, $OCH_2Ar$), 4.95 (d, 2H, $OCH_2Ar$), 5.05 (d, 2H, $OCH_2Ar$), 7.19 (d, 2H, ArH), 7.23 (d, 2H, ArH), 7.28 (d, 2H, ArH); IR (KBr, $\nu_{max}$, $cm^{-1}$): 1750, 1190.

**Preparation of compound 3:** Compound **2a** (0.54 g, 0.64 mmol) added in 20 mL mixed solution of methanol/toluene (1:1, v/v), then added *tris*-(2-amino-ethylamine) (0.1 g, 0.64 mmol). The solution was refluxed for 2 days under the nitrogen atmosphere and then cooled to room temperature. Removed the solution under reduced pressure, the residue was recrystallized with ethanol, get pure white crystals (**3**) (0.21g, 38%). m.p. > 300 ºC. $^1$H NMR (500 MHz, $CDCl_3$): δ (ppm) 1.14 (s, 27H, *t*-Bu), 2.72 (t, 6H, $NCH_2$), 3.40 (t, 6H, $NHCH_2$), 4.23 (s, 6H, $OCH_2CO$), 4.36 (d, 6H, $ArCH_2O$). 4.60 (d, 6H, $ArCH_2O$), 6.95 (s, 6H, ArH), 8.02 (s, 3H, NH). IR (KBr, $\nu_{max}$, $cm^{-1}$): 3412, 3376, 2960, 2864, 1678, 1450, 882.

**Preparation of compound 4:** Compound **3** was acidified with hydrochloric acid (pH = 3) and recrystallized from ethanol to give compound **4**, m.p. 215-217 ºC. $^1$H NMR (500 MHz, $CDCl_3$): δ (ppm) 1.140 (s, 27H), 2.724 (t, 6H), 3.385 (t, 6H), 4.214 (s, 6H), 4.405 (d, 6H, *J* = 12), 4.886 (d, 6H, *J* = 12), 6.951 (s, 6H). IR (KBr, $\nu_{max}$, $cm^{-1}$): 3432, 3283, 3070, 2959, 2907, 2868, 1678, 1564, 1454, 1258, 1062.

**Crystallography:** Crystals of compound **4** suitable for X-ray investigation was obtained from ethanol by slow evaporation solvents. Determination of the unit cell and data collection (Table-1) was performed on a Bruker Apex-II CCD diffractometer using graphite monochromated $MoK_\alpha$ radiation ($\lambda$ = 0.71073Å) at 293 (2)K with crystal size 0.20 × 0.15 × 0.25 $mm^3$. A total of 55377 ($R_{int}$ = 0.0485) independent reflections were collected by ω-2θ scan technique in the range 1.44 ≤ q ≤ 27.52º from which 6565 [I>2σ(I)] reflection were corrected for Lorentz and polarization factors. The structure was solved by direct method using SHELXS-97 and refined using a full-matrix least-squares procedure on $F^2$ in SHELXS-97. All non-hydrogen atoms were refined wits anisotropic thermal parameters. Hydrogen atoms were added theoretically and refined with riding model position parameters and fixed with isotropic thermal parameters. (CCDC: 759964).

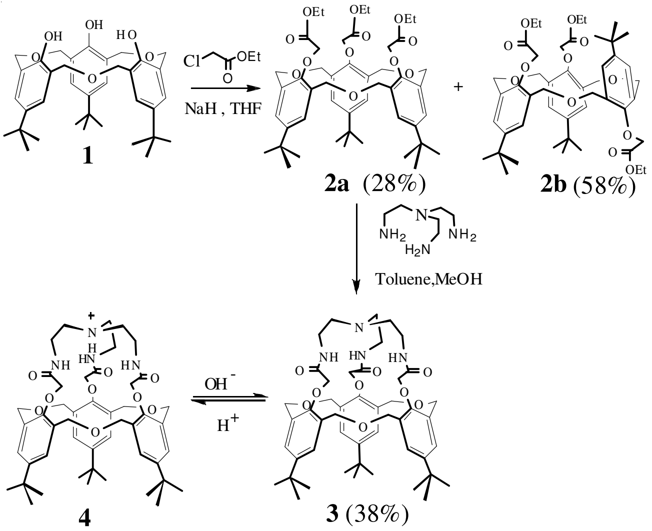
## RESULTS AND DISCUSSION

The synthetic route of compound **4** is presented in **Scheme-I**. The key process of synthesis of compound **4** is making sure that get a fixed cone conformation, because the specific conformation is not only depends on temperature and solvent, but is also controls by the introduced functional moiety. Compound **4** was synthesized using compound **2a** and the *tris*-(2-amino-ethylamine) as the starting materials with a high yield.

The molecular structure of compound **4** is illustrated in Fig. 1. Its crystallization in the monoclinic system (space group C 2/c 1), a = 19.6831(16) Å, b = 16.8180(16) Å, c = 29.267(3) Å, α = 90º, β = 105.222(4)º, γ = 90º. It is clearly suggested that compound **4** adopts a cone conformation, three calix benzene rings tilt towards the cavity and maintain a normal cone conformation; the dihedral angles of the three calixarene benzene Ring 1 (C5-C6-C7-C8-C9-C10) and Ring 2 (C21-C22-C23-C24-C25-C26), Ring 2 and Ring 3 (C37-C38-C39-C40-C41-42), Ring 3 and Ring 1 have the values 80.56(6)º, 33.56(5)º and 55.48(7)º, respectively. The carbonyl oxygens (O1, O4, O7) are orientated outside, against the concave cavity. The torsion angles N1-C1-C2-N2, N1-C17-C18-N3, N1-C33-C34-N4 are -67.6(3)º, -70.8(2) º, and -59.6(3)º. The ether linkage C15-O9-C16, C31-O3-C32 are 111.84(14)º, 115.76 (15)º. Orientated downward, and the C47-O6-C48 is orientated upward. Three aliphatic chains (N1-C1-C2-N2-C3-C4-O8, N1-C17-C18-N3-C19-C20-O2, N1-C33-C34-N4-C35-C36-O5) are oriented randomLy between the top nitrogen atom and calix benzene, they do not adhere to the $C_{3v}$-symmetrical conformation. For example, the distances between the carbonyl carbon atoms (C3-C19-C35-C3) are 5.278 Å, 5.248 Å, and 6.894 Å, respectively.

TABLE-1
DATA COLLECTION AND PROCESSING PARAMETERS FOR COMPOUND **4**

| | | | |
|---|---|---|---|
| Formula | $C_{48}H_{66}N_4O_9$ | Volume (Å$^3$) | 9348.2(14) Å |
| Formula weight | 843.5 | Z | 8 |
| Crystal system | Monoclinic | D(calc), Mg $cm^{-3}$ | 1.198 |
| Space group | C 2/c 1 | μ ($mm^{-1}$) | 0.86 |
| Temperature | 293 K | 2θ max (º) | 50 |
| No. of params | 550 | N ind | 10626 |
| R | 0.0541 | GOF | 1.033 |
| Rw | 0.1335 | F(000) | 3632 |



**Scheme-I**: Synthetic scheme for the preparation of capped hexahomotrioxacalix[3]arene derivative

## Conclusion

In summary, the structure of compound **4** has been first determined by X-ray analysis, which showed a fixed cone conformation and capped by tris-(2-amino-ethylamine) at the lower rim. This compound has such advantages as easily synthesis, highly yield and controllable conformation. The special novel configuration give this molecule better performance, the properties of the compound need further experimental and theoretical study.

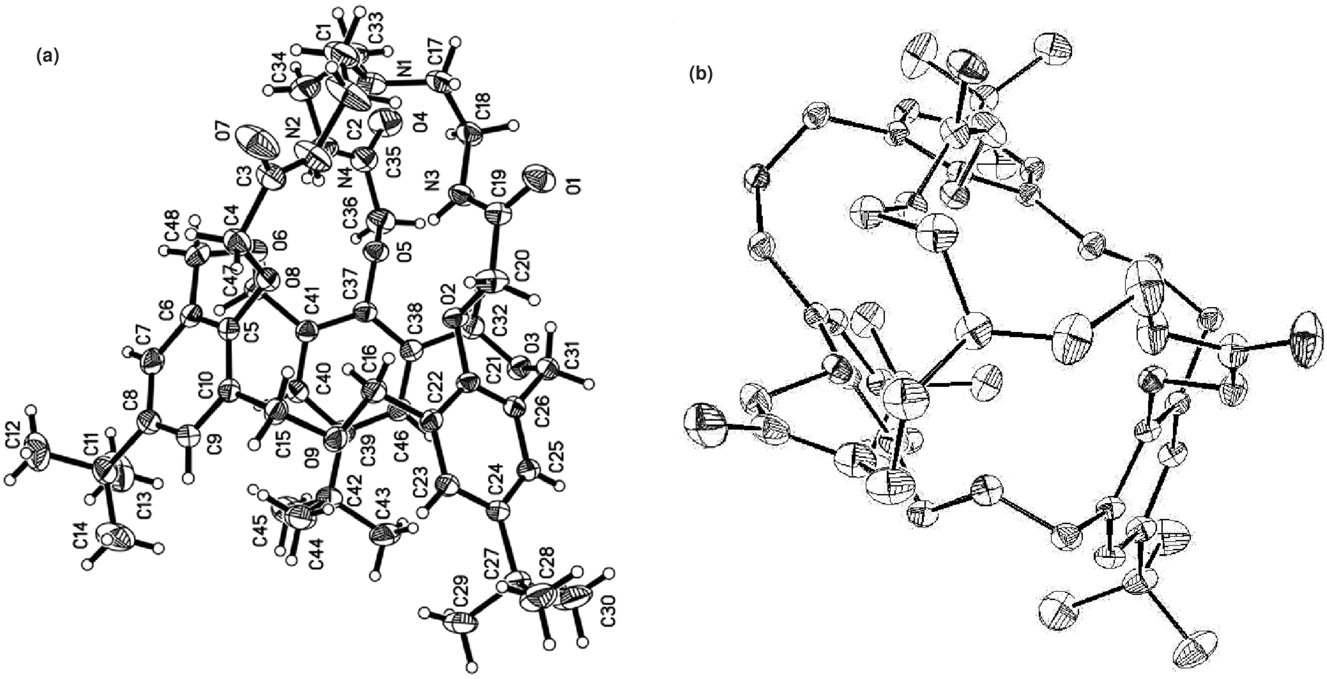


Fig. 1. X-ray structure of capped compound **4**, hydrogen atoms are omitted for clarity. (a) The side view of X-ray structure of compound **4**. (b) The top view of X-ray structure of compound **4**

## ACKNOWLEDGEMENTS

The authors are grateful for the financial support from the Fund of the International Cooperation Projects of Guizhou Province (No. 20107002), Chun-Hui Fund of Chinese of Education (No. Z 2009-1-52001) and Natural Science Foundation of China (No. 21165006).

## REFERENCES

1. B. Xu and T.M. Svager, *J. Am. Chem. Soc*., **115**, 1159 (1993).
2. P. Zerr, M. Mussrabi and J. Vicens, *Tetrahedron Lett*., **32**, 1879 (1991).
3. N. Morohashi, F. Narumi, N. Iki, T. Hattori and S. Miyano, *Chem. Rev*., **106**, 5291 (2006).
4. W.T. Bell and M.N. Hext, *Chem. Soc. Rev*., **33**, 589 (2004);
5. C. Wu, W.J. Zhang, X. Zeng, L. Mu, S.F. Xue, Z. Tao and T. Yamato, *J. Incl. Phenom. Macrocycl. Chem*., **66**, 125 (2010).