Pergamon

Tetrahedron Letters 40 (1999) 5865–5868

TETRAHEDRON
LETTERS

Fluorenylidene-diphenyl-crown-ethers

Annick Nehlig,[a] Gérard Kaufmann,[b] Zouhair Asfari,[a] and Jacques Vicens[a]*

(a) ECPM, Laboratoire de Chimie Minérale et de Chimie Analytique, associé au CNRS
25, rue Becquerel, F-67087 Strasbourg cédex 2, France
(b) ULP, Laboratoire de Modèles Appliqués à la Synthèse, associé au CNRS
1, rue Blaise Pascal, F-67008 Strasbourg, France

Received 17 May 1999; accepted 15 June 1999

Abstract : It is reported the synthesis and characterization of [22]-[88]-membered crown ethers **1-4** including *bis*(hydroxyphenyl) fluorene in the macroring. Molecular modelling has been performed on **1-4** to rationalize the observed yields during the synthesis. © 1999 Published by Elsevier Science Ltd. All rights reserved.

Keywords: crown-ethers, large ring macrocycles, molecular modelling.

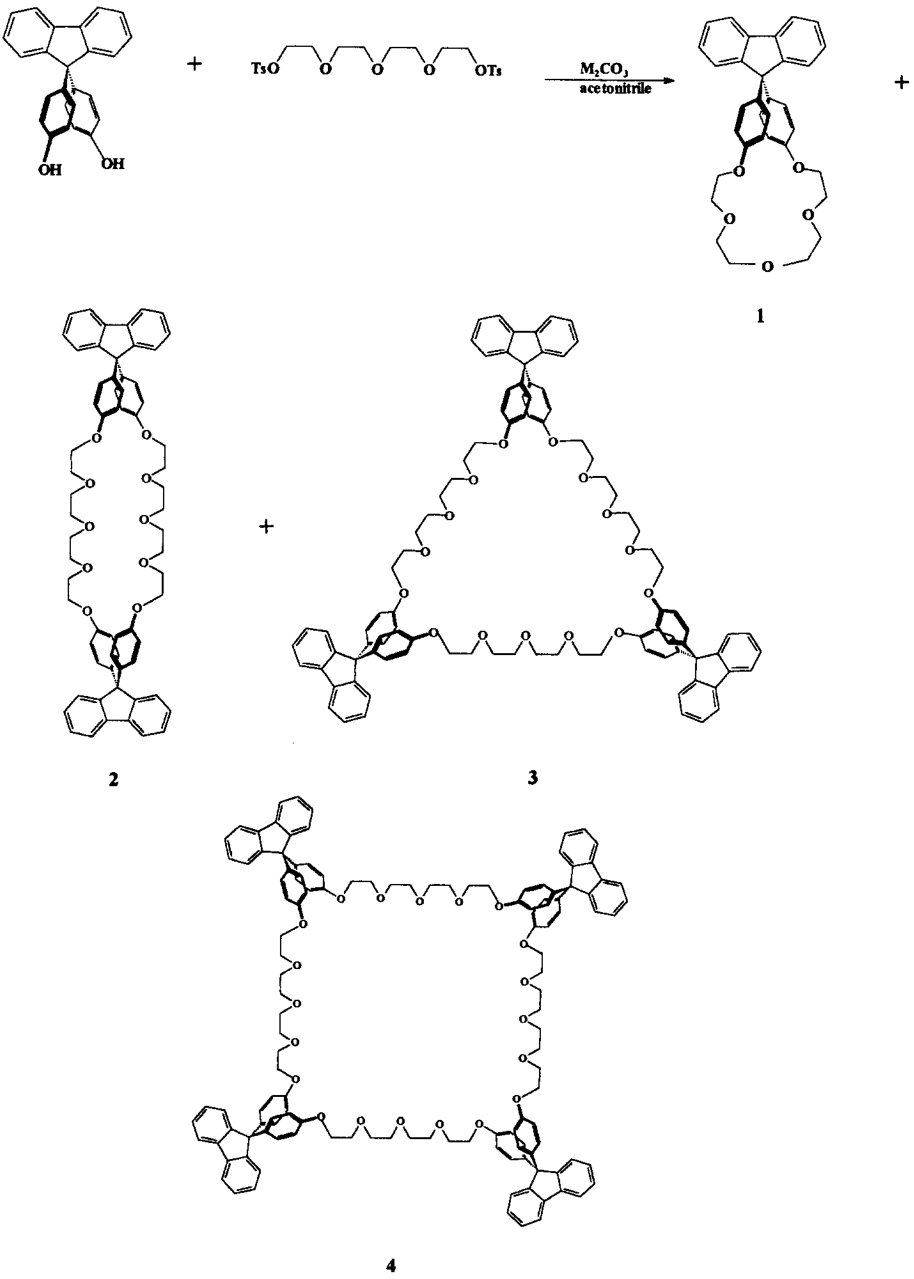
Supramolecular chemistry is the chemistry of intermolecular bonds. It involves the development of macrocyclic molecules such as crown ethers, cryptands, cyclophanes etc. to provide the chemist with molecular structures that can serve as building blocks for more complicated molecules and subsequent higher supramolecular structures. In this respect attention has been paid to the synthesis of large ring molecules.[1] Among them large circular crown ethers have been described. In 1985, Prelog et al.[2] reported the synthesis of a series of poly(9,9'-spirobifluorene) crown ethers as potential chiral hosts the largest one being 104-membered. More recently, the interest in large (>24-membered) crown ethers[3] stems from their utilisation in the synthesis of (pseudo)rotaxanes in which one component is thread through the cavity of the crown ether structure.[4] Interestingly a 32-membered dibenzo crown ether has been observed to complex secondary components.[5]

In the present Note we report the synthesis, characterization of the [22]-[88]-membered crown ethers **1-4** including *bis*(hydroxyphenyl) fluorene[6] in the macroring.

According to scheme 1, the synthesis began by reacting 9,9-*bis*-(4-hydroxyphenyl)-fluorene with 1 equiv of tetraethylene glycol ditosylate in the presence of 5 equivs of M_2CO_3 (M= K, Rb, and Cs) in refluxing acetonitrile for 4 days.[7]

*Fax: [33](0)388136932 E-mail: vicens@chimie.u-strasbg.fr

PII: S0040-4039(99)01155-7



Scheme 1. Synthesis of **1-4**.

Crown ethers **1**-**4** were obtained pure by column chromatography and were characterized by ^{1}H-NMR, FAB(+) MS, and elemental analysis.[7] Yields are given in Table 1.

Table 1. Yields of isolated crown ethers **1**-**4**.

Crown ethers	**K_2CO_3**	**Rb_2CO_3**	**Cs_2CO_3**
1	1 %	-	-
2	20%	25 %	18 %
3	6%	7 %	9 %
4		3 %	7 %

Table 1 shows that **1** is obtained only when using K_2CO_3 as base and in poor yield. Product **2** is obtained with the best yields whatever the base. Products **3** and **4** are formed when increasing the size of the M^+ by using Rb_2CO_3 or Cs_2CO_3.

These results led us to perform a molecular modelling study of crown ethers **1**-**4** with SYBYL v6.1 program from Tripos[8] to investigate their structures from a topological point of view and to provide informations on their potential cation-complexing properties (see Figure 1).

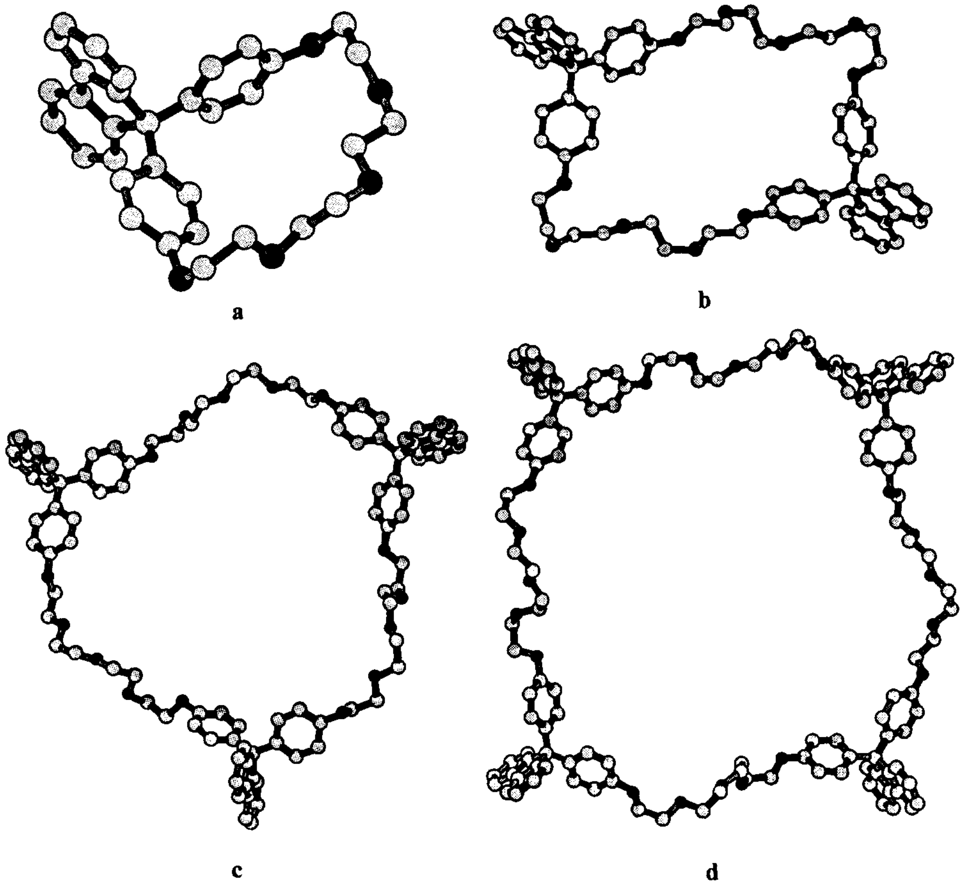


Figure 1. Molecular modelling of **1**-**4**.

In molecule **1**, depicted as (a) in figure 1, the distance between the two phenolic oxygens is 9.44 Å leading to a highly constrained structure explaining the very low yield. Once the first reaction of the phenolate on the tosylate has occured, the cyclisation is made difficult and the formation of **2** is preferred if one takes into account a template effect with two cations[9] (see below the dimension of the cavity of **2** which matches with the inclusion of two cations). The glycolic oxygen atoms are approximatively located in the same plane with a maximal distance from the plane of ± 0.5 Å. In the structures (a) and (b), the oxygen atoms make elliptic cavities, the centroïds of which are situated at the average distances of 3.86 Å and 6.56 Å from the oxygen atoms of the macroring. On the other hand, the structures (c) and (d), the oxygen atoms make a roughly circular cavity : the average radii of the cavities are approximatively 10.0 Å and 12.2 Å.

We are currently carrying out similar reactions with polyethylene glycol ditosylates with various lenghts and using the largest macrocycles to form poly(pseudo)rotaxanes.[10]

References and notes

1. Semlyen, J. A. *Large Ring Molecules*, John Wiley & Sons, New York, 1996.
2. Dobler, M.; Dumic, M.; Egli, M.; Prelog, V. *Angew. Chem. Int. Ed. Engl.* **1985**, *24*, 792-794.
3. Gibson, H. W.; Bheda, M. C.; Engen, P.; Shen, Y. X.; Sze, J.; Zhang, H.; Gibson, M. D.; Delaviz, Y.; Lee, S.-H.; Liu, S.; Wang, L.; Nagvekar, D.; Rancourt, J.; Taylor, T. L. *J. Org. Chem.* **1994**, *59*, 2196.
4. Amabilino, D. B.; Stoddart, J. F. *Chem Rev.* **1995**, *95*, 2725-2828; Fyfe, M. C.; Stoddart, J. F. *Acc. Chem. Res.* **1997**, *30*, 393-401; Balzani, V.; Gomez-Lopez, M.; Stoddart, J. F. *Acc. Chem. Res.* **1998**, *31*, 405-414.
5. Bryant, W. S.; Guzei, I. A.; Rheingold, A. L.; Merola, J. S.; Gibson, H. W. *J. Org. Chem.* **1998**, *63*, 7634-7639.
6. The synthesis of poly(arylene ether)s based on related 9,9-bis(diphenyl-3,5-hydroxyphenyl)fluorene has been described by Wang, Z. Y. ; Hay, A. S. *J. Polymer Sci., Part A* **1991**, *29*, 1045-1052.
7. **General:** Mps, capillaries under nitrogen, Büchi 500. Chromatography, SiO_2 columns with Kieselgel Merck (Art. 11567). ^{1}H-NMR in $CDCl_3$, Bruker SY200 (δ in ppm, J in Hz), FAB (+), VG-Analytical ZAB HF. Elemental analyses performed at the Service de Microanalyse of the Institut de Chimie de Strasbourg.

   Typical procedure for preparing 1-3 : 9,9-bis-(4-hydroxyphenyl)-fluorene (1.066 g ; 3.05 mmol), tetraethylene glycol ditosylate (1.581 g ; 3.15 mmol), K_2CO_3 (2.163 g ; 15.67 mmol), and acetonitrile (200 mL) were refluxed for 4 days. After removing the solvents. The crude mixture was solubilized in CH_2Cl_2 and acidified with 1 N HCl to pH~1. The organic layer was dried over Na_2SO_4. The residue was chromatographed on silica column with a mixture 90:10 CH_2Cl_2-acetone. Products **1-3** were eluted in this order.

   Crown ether 1 : white solid, mp 79-81 °C. ^{1}H-NMR (200 MHz, $CDCl_3$) 7.75 (d, $J=7.0$, 2H, Ar-*H*),7.55 (d, $J=7.0$, 2H, Ar-*H*), 7.30 (m, 4H, Ar-*H*), 7.05 (d, $J=9.0$, 4H, Ar-*H*), 6.95 (d, $J=9.0$, 4H, Ar-*H*), 4.30 (t, $J=5.0$, 4H, ArOCH_2CH_2), 3.74 (d, $J=5.0$, 4H, OCH_2CH_2), 3.58 (d, $J=5.0$, 4H, OCH_2CH_2), 3.50 (d, $J=5.0$, 4H, OCH_2CH_2). FAB(+) MS, *m/z* 509.3. *Anal. Cacld.* For $C_{33}H_{32}O_5$: C,77.92; H,6.35. *Found* C,77.84; H,6.15. **Yield 1%**.

   Crown ether 2 : white solid, mp 102-103 °C. ^{1}H-NMR (200 MHz, $CDCl_3$) 7.70 (d, $J=7.0$, 4H, Ar-*H*), 7.20 (m, 12H, Ar-*H*), 7.10 (d, $J=9.0$, 8H, Ar-*H*), 6.70 (d, $J=9.0$, 8H, Ar-*H*), 4.04 (t, $J=5.0$, 8H, ArOCH_2CH_2), 3.80 (t, $J=5.0$, 8H, OCH_2CH_2), 3.67-3.64 (m, 16H, OCH_2CH_2). FAB(+) MS, *m/z* 1017.4. *Anal. Cacld.* For $C_{66}H_{64}O_{10}$: C,77.92; H,6.35. *Found* C,77.98; H,6.20. **Yield 20%**.

   Crown ether 3 : white solid, mp 118-121 °C. ^{1}H-NMR (200 MHz, $CDCl_3$) 7.70 (d, $J=7.0$, 6H, Ar-*H*), 7.25 (m, 18H, Ar-*H*), 7.10 (d, $J=9.0$, 12H, Ar-*H*), 6.70 (d, $J=9.0$, 12H, Ar-*H*), 4.00 (t, $J=5.0$, 12H, ArOCH_2CH_2), 3.77 (t, $J=5.0$, 12H, OCH_2CH_2), 3.65-3.60 (m, 24H, OCH_2CH_2). FAB(+) MS, *m/z* 1525.7. *Anal. Cacld.* For $C_{99}H_{96}O_{15}$: C,77.92; H,6.35. *Found* C,78.12; H,6.28. **Yield 6%**.

   In similar procedures with Rb_2CO_3 or Cs_2CO_3 we isolated **crown ether 4 :** white solid, mp 95-97 °C. ^{1}H-NMR (200 MHz, $CDCl_3$) 7.70 (d, $J=7.0$, 8H, Ar-*H*), 7.20 (m, 24H, Ar-*H*), 7.10 (d, $J=9.0$, 16H, Ar-*H*), 6.70 (d, $J=9.0$, 16H, Ar-*H*), 4.00 (t, $J=5.0$, 16H, ArOCH_2CH_2), 3.75 (t, $J=5.0$, 16H, OCH_2CH_2), 3.66-3.58 (m, 32H, OCH_2CH_2). FAB(+) MS, *m/z* 2034.9. *Anal. Cacld.* For $C_{132}H_{128}O_{20}$: C,77.92; H,6.35. *Found* C,77.85; H,6.18.
8. Tripos inc. 1699 South Hanley Road, St Louis, MO 63144 , USA. http://www.tripos.com
9. Gokel, G., *Crown Ethers & Cryptands*, Monographs in Supramolecular Chemistry, Stoddart, J. F. (ed.), The Royal Society of Chemistry, Cambridge, 1991.
10. Fyfe, M. C.; Glink, P. T.; Menzer, S.; Stoddart, J. F. ; White, A. J. P. ; Williams, D. J. *Angew. Chem. Int. Ed. Engl.* **1997**, *36*, 2068-2069.