

## Synthesis of New Aza-crown Ethers Containing Pyridine Ring and their Liquid Membrane Transport of Alkali Cations

Bin ZHAO<sup>1\*</sup>, Feng Qin WANG<sup>1</sup>, Min XIA<sup>2</sup>, Lai Jin TIAN<sup>1</sup>

<sup>1</sup>Department of Chemistry, Qufu Normal University, Qufu 273165

<sup>2</sup>Department of Chemistry, Linyi Teacher's College, Linyi 276000

**Abstract:** Five new aza-crown ethers have been prepared by the condensation of 2,6-bis[(2-formylphenyl)oxymethyl] pyridine with different diamino compounds in hot methanol, the bis-Schiff bases without isolation were reduced with NaBH<sub>4</sub> to afford the corresponding aza-crown ethers. The liquid membrane transport of alkali cations using the five new macrocycles as the ion-carriers was also studied.

**Keywords:** Aza-crown ether, macrocycle, receptor, liquid membrane transport, picrate.

### Introduction

Oxygen donor macrocycles such as crown ethers are well known to have strong complexation for alkali and alkaline earth ions<sup>1</sup>. On the other hand, polyazamacrocycles show a high affinity for transition metal ions. Nitrogen-oxygen mixed donor macrocycles can form stable complexes with both alkali and transition metal ions<sup>2-5</sup>. Most of the macrocycles with mixed donor sites bearing oxygen and sp<sup>3</sup> nitrogen atoms, oxygen and sp<sup>2</sup> nitrogen atoms, or oxygen and sp<sup>3</sup> and sp<sup>2</sup> nitrogen atoms have shown very interesting behavior in metal ions discrimination.

In this paper, five new nitrogen-oxygen donor macrocycles **8a~8e** incorporating sp<sup>2</sup> and sp<sup>3</sup> nitrogen atoms were synthesized in six steps from the commercially available starting materials. The synthetic routes for the new macrocycles are shown in **Scheme 1**. The liquid membrane transport of alkali cations using the five new macrocycles **8a~8e** as the ion-carriers was also studied.

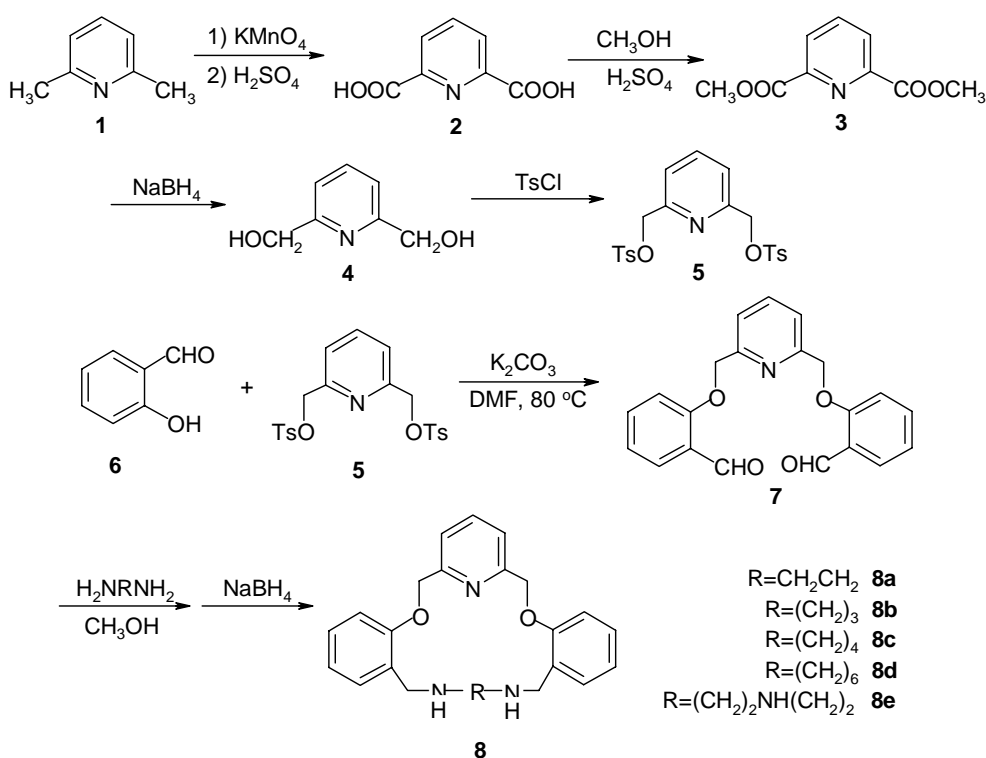
### Experimental

2,6-Pyridine dicarboxylic acid **2**, dimethyl 2,6-pyridine dicarboxylate **3**<sup>6</sup>, 2,6-di(hydroxy-methyl) pyridine **4**<sup>7</sup> and 2,6-di (tosyloxymethyl) pyridine **5**<sup>8</sup> were prepared according to the literature methods.

*Preparation of 2,6-bis [(2-formylphenyl) oxymethyl] pyridine 7*

Salicylaldehyde (8.5 g, 0.07 mol), potassium carbonate (11 g) and DMF (80 ml) were placed in a three-necked, N<sub>2</sub> flushed flask. The mixture was warmed to *ca* 80 °C and 2,6-di (tosyloxymethyl) pyridine (13.4 g) was added. The reaction mixture was stirred vigorously at 80 °C for 10 h. After cooling down, the reaction mixture was poured into ice-water (200 ml). The pale yellow solid was filtered, washed with water and then dried. Recrystallization from methanol gave white crystals of the dialdehyde **7**, yield 75%. m.p. 136-138 °C.

Scheme 1



#### Preparation of macrocycles **8a-8e**

To a refluxing solution of dialdehyde **7** (1.40 g, 0.004 mol) in methanol (200 ml) ethylenediamine (0.24 g, 0.004 mol) in methanol (50 ml) was added. After addition of ethylenediamine, the reaction solution was kept stirring for 5 min, and then a small amount of borax followed by sodium borohydride (0.8 g) was added slowly to the solution and the mixture was stirred for another 3 h. The reaction solution was filtered and concentrated in reduced pressure. The residue was dissolved in water (60 ml) and extracted with chloroform (3 × 50 ml). The chloroform extracts were washed with water, dried over anhydrous sodium sulfate and then evaporated to dryness to afford the

crude oily product, which eventually crystallized to form a white solid. Recrystallization from chloroform-ether gave white crystals of **8a**, yield 70%. m.p. 138-140°C.

**8b~8e** were prepared according to the same procedure as for **8a**. The yields, melting points and the elemental analysis data of **8a~8e** are shown in **Table 1**.

**Table 1** The melting points and elemental analysis data of **8a~8e**

Compd	Formula	m.p. (°C)	Yield (%)	Elemental Analysis: Found(Calcd)		
				C	H	N
<b>8a</b>	C <sub>23</sub> H <sub>25</sub> N <sub>3</sub> O <sub>2</sub>	138-140	70	72.9(73.6)	6.75(6.67)	10.3(11.2)
<b>8b</b>	C <sub>24</sub> H <sub>27</sub> N <sub>3</sub> O <sub>2</sub>	128-130	72	73.5(74.1)	7.08(6.94)	9.92(10.8)
<b>8c</b>	C <sub>25</sub> H <sub>29</sub> N <sub>3</sub> O <sub>2</sub>	63-65	68	75.2(75.4)	7.09(7.20)	9.89(10.4)
<b>8d</b>	C <sub>27</sub> H <sub>33</sub> N <sub>3</sub> O <sub>2</sub>	74-76	74	76.2(75.2)	7.78(7.66)	8.87(9.74)
<b>8e</b>	C <sub>25</sub> H <sub>30</sub> N <sub>4</sub> O <sub>2</sub>	oil	65	72.6(71.8)	7.36(7.18)	12.5(13.4)

#### *Cation transport through a liquid membrane*

The apparatus used for the liquid membrane transport is as described in the literature<sup>9</sup> [Magnetic bar: 2.6 mm in length and 0.7 mm in diameter, 1.5 turns per second. Phase 1 (the source phase): 15 ml aqueous solution of alkali picrate ( $1 \times 10^{-3}$  mol/L) and nitrate (0.1 mol/L). Phase 2 (receiving phase): deionized water (15 ml). Phase 3 (liquid membrane): dichloromethane solution (45 ml) of the macrocycle to be studied ( $5 \times 10^{-5}$  mol/L)

The transport was performed at  $25.0 \pm 0.5^\circ\text{C}$ . The appearance of the picrate anion in phase 2 was detected by UV-vis spectrophotometer at 355.0 nm for KPic and 345.5 nm for NaPic.

#### **Results and discussion**

In the synthesis of the macrocycles **8a~8e**, the dialdehyde was condensed with different diamines in hot methanol. The corresponding Schiff base derivatives without isolation were reduced with sodium borohydride. The condensation reaction can be performed at room temperature over a long period of time. The reduction step can also be carried out at room temperature. The overall yields of two steps were in range of 65~72%. It is not necessary to carry out the ring closure step under high dilution conditions. The structures of the new macrocycles are consistent with the spectroscopic data and elemental analysis<sup>10</sup>.

To test the ability of these macrocycles to extract and release alkali metal cations, their role as transport agents across a liquid membrane were studied. The transport of Na<sup>+</sup> and K<sup>+</sup> cations was studied separately from an aqueous solution which contained a mixture of alkali metal picrate and nitrate. The transport co-anion was the picrate because of its lipophilic. This effect allowed a good incorporation in the organic phase containing the macrocycle. There was no transport of picrate ion across the membrane in case of absence of the macrocycles. For the transport by cryptates possessing tertiary

amines, Kirch and Lehn<sup>11</sup> have demonstrated that the protonation of these ligands occurs to a significant extent. Therefore, the deionized water used in the experiments was adjusted to pH 8 with NaOH or KOH to avoid the protonation of the macrocycles.

The transport rates and selectivity ratios were given in **Table 2**. The results showed that the transport rates of Na<sup>+</sup> followed the order of **8a**>**8b**>**8c**>**8e**>**8d**, and the transport rates of K<sup>+</sup> showed the following order: **8a**<**8b**<**8c**<**8e**<**8d**. **8a** had the highest selectivity for Na<sup>+</sup> while **8d** had the highest selectivity for K<sup>+</sup>.

**Table 2** Transport rates and selectivity ratios

Ligand	Transport rate (mol/h × 10 <sup>7</sup> )		Transport selectivity ( $\gamma_{\text{Na}^+}/\gamma_{\text{K}^+}$ )
	Na <sup>+</sup>	K <sup>+</sup>	
<b>8a</b>	7.72	0.83	9.31
<b>8b</b>	6.85	4.87	1.35
<b>8c</b>	5.07	5.31	0.95
<b>8d</b>	4.07	6.01	0.68
<b>8e</b>	4.62	6.35	0.73

### Acknowledgment

We are grateful to the Natural Science Foundation of Shandong Province for financial support of this work (Q97B03123).

### References and notes

1. F. Vogtle, *Top. Curr. Chem.*, **1981**, 98, 1.
2. V. J. Tom, M. S. Shaikjee, R. D. Hancock, *Inorg. Chem.*, **1986**, 25, 2992.
3. R. M. Izatt, J. S. Bradshaw, S. A. Nielsen, J. D. Lamb, J. J. Christensen, D. Sen, *Chem. Rev.*, **1985**, 85, 271.
4. R. M. Izatt, K. Pawlak, J. S. Bradshaw, R. L. Bruening, *Chem. Rev.*, **1991**, 91, 1721.
5. S. R. Cooper, *Crown compounds towards future applications*, VCH Publisher, New York, **1992**, 1.
6. R. J. Motekaitis, A. E. Martell, *Inorg. Chem.*, **1988**, 27, 2718.
7. M. Newcomb, J. M. Timke, D. M. Walba, D. J. Cram, *J. Am. Chem. Soc.*, **1977**, 99, 6392.
8. J. S. Bradshaw, P. Huszthy, C. W. McDaniel, C. Y. Zhu, N. K. Dalley, R. M. Izatt, S. Lifson, *J. Org. Chem.*, **1990**, 55, 3129.
9. B. Zhao, Y. J. Wu, J. C. Tao, H. Z. Yuan, X. A. Mao, *Polyhedron*, **1996**, 15, 1197.
10. The data of IR, UV and NMR have been deposited in the editorial office of CCL.
11. M. Kirch, J. M. Lehn, *Angew. Chem., Int. Ed. Engl.*, **1975**, 14, 555.

Received June 12, 2000