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Three new macrocyclic polyether-diester have been prepared. The catalytic activity of these compounds has been tested in the Br/I exchange reactions of octyl bromide with different ionic diameter cations.

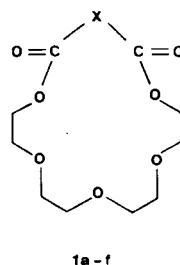
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After Pedersen's discovery of crown compounds [1], many investigators have published books and papers on the synthesis of macrocyclic polyethers and on various aspects of complexation reactions [2-7]. In the last years one of the main research objectives has been to prepare new macrocyclic compounds for use in various fields of chemistry. Continuing our research in the field of macrocyclic chemistry [8], we have reported the synthesis of macrocyclic tetraesters and studied their behaviour in some phase-transfer catalysis reactions [9]. The method for synthesizing these tetraesters consisted of the reaction between the dioxastannolic and/or dioxastibolonic derivatives and diacyl chlorides. The tetraester products were obtained in good yields using short reaction times. The catalytic activity of these macrocyclic tetraesters was shown in some nucleophilic substitution reactions and compared with the activity of other macrocycles. Although the tetraesters contained six oxygen donor atoms, they did not show selectivity towards one or another of the studied cations [9].

In the present paper, the preparation of the new compounds **1c-e** following the method of Bradshaw and co-workers [10] is described and a study of catalytic activity on some substitution reactions is reported. The macrocycles were prepared at high dilution by adding the tetraethylene glycol and diacyl chlorides to benzene at 50-60° and stirring for some days. Yields were generally in the range of 31-33%.

The structures proposed for the macrocycles have been determined by analytical and spectroscopic data. All the ir spectra of the macrocycles **1c-e** exhibited bands at 1730-1740 cm<sup>-1</sup> due to the carbonyl group. The nmr spectra exhibited signals at  $\delta$  4.13  $\pm$  0.03, 3.56  $\pm$  0.02, 2.23  $\pm$  0.1 attributable to groups COOCH<sub>2</sub>, CH<sub>2</sub>OCH<sub>2</sub> and CH<sub>2</sub>-CO; the inner methylene groups showed a multiplet between  $\delta$  1.1-1.76. All the mass spectra of macrocycles showed [M + H]<sup>+</sup> ions more abundant than [M]<sup>+</sup>.

Although they possess the same ring coordination sites, these macrocyclic polyether diester compounds differ in ring size. They can complex alkali cations, thus acting as



**1a-f**

- a x = -CH<sub>2</sub>-
- b x = -(CH<sub>2</sub>)<sub>3</sub>-
- c x = -(CH<sub>2</sub>)<sub>5</sub>-
- d x = -(CH<sub>2</sub>)<sub>7</sub>-
- e x = -(CH<sub>2</sub>)<sub>8</sub>-
- f x = -CH<sub>2</sub>-O-CH<sub>2</sub>-

Scheme 1

catalysts in nucleophilic aliphatic substitutions under PTC conditions. It has been reported [11] that the main parameters affecting the affinity of macrocycles such as crown ethers for metal cations include the ratio of the cation diameter to the macrocycle cavity diameter. In the nucleophilic substitution of the Br<sup>-</sup> group in *n*-octyl bromide by I<sup>-</sup>, conducted under two-phase conditions in presence of catalytic amounts of **1a-f**, the relative catalytic activities of these compounds differ in function of the ionic diameter of employed cations. The data in Table 1 indicate that, keeping the hydrophobic character of catalysts **1a-e** constant and changing their lipophylic nature by increasing the aliphatic chains of the diacyl groups, the yields of *n*-octyl iodide of the Br/I exchange reactions do not improve and they are obtained in longer times with respect to the crown ethers investigated by Montanari and co-workers [16]. As previously reported [9], these results may be due to the introduction of carbonyl groups, which do not contribute directly to the catalytic activity, in the crown ether ring. Among the studied catalysts, **1c** and **1d** exhibit a slightly better catalytic activity than **1a,b** and **1e**, and this depends on the cationic species. With all these catalysts remarkably low catalytic activity was found with the lithium cation.

Table 1

Influence of the Catalyst on the Nucleophilic Reaction  $C_6H_{17}Br + MI \rightarrow C_6H_{17}I + MBr$  Carried out Under Phase-Transfer Conditions [a]

Reagent [b]	Catalyst [c]	Reaction time hours	Yields % [e]	Reagent [b]	Catalyst [c]	Reaction time hours	Yields % [e]
LiI	1a	48	15	RbI	1a	48	7
	1b	48	13		1b	48	15
	1c	48	13		1c	48	60
	1d	48	19		1d	48	63
	1e	48	22		1e	48	25
	1f	48	23		1f	24 (48)	9 (16)
NaI	1a	48	7	CsI	1a	48	18
	1b	48	11		1b	48	21
	1c	48	52		1c	48	39
	1d	48	33		1d	48	51
	1e	48	25		1e	48	41
	1f [d]	24	18		1f	24 (48)	17 (25)
KI	1a	48	8	NH <sub>4</sub> I	1a	48	17
	1b	48	15		1b	48	20
	1c	48	62		1c	48	52
	1d	48	63		1d	48	50
	1e	48	36		1e	48	51
	1f [d]	24	27		1f [d]	24 (48)	32 (38)

[a] The reactions were carried out at 80° with a saturated aqueous solution of the reagent, no solvent was used for the substrate which was  $C_6H_{17}Br$  throughout. [b] 5 Molar equivalents. [c] 0.05 Molar equivalents. [d] From ref [9]. [e] Yields of the product,  $C_6H_{17}I$  were determined by glc. Characterization was by comparison with authentic samples (ir and nmr spectra).

In the alkylation of ketones with 1-bromobutane the catalytic activity of **1a-e** is about the same order as the macrocyclic tetraesters previously studied [9], but lower than that of **1b** (Table 2).

Table 2

Alkylation Reactions Under Phase-Transfer Conditions

 $Ph-CH_2-CO-CH_3 + n-BuBr$  [a]  $\rightarrow$   $Ph-CH(n-C_4H_9)-CO-CH_3$  [d]

Catalyst [b]	T, °C	Reaction Time hours	Yield % [c]
name	60	24	< 2
1a	60	24	30
1b	60	24	75
1c	60	24	45
1d	60	24	43
1e	60	24	53
1f [e]	60	24	66

[a] 1.2 Molar equivalents in 30% aqueous sodium hydroxide. [b] 0.05 Molar equivalent. [c] By glc analysis. [d] Products were characterized by glc retention time. [e] From ref [9].

## EXPERIMENTAL

Tetraethylene glycol, malonyl dichloride, glutaroyl dichloride, azeloyl dichloride, and sebacoyl dichloride were commercial samples and used as received. Literature procedures were followed in the preparation of pimeloyl dichloride [12]. Diglycolyl dichloride was prepared from the commercially available acid by the method of Dietrich [13]. Crown ether-

diesters **1a,b** and **1f** were synthesized and purified as described in literature [14,15]. All products were identified by analytical and spectroscopic data. Merck silica gel (70-230 mesh) was used for column chromatography; thin layer separation was carried out by Merck F254 silica gel and visualization was accomplished by uv light. All infrared spectra were obtained on a Perkin Elmer model 157G spectrophotometer. The proton nuclear magnetic resonance spectra were obtained on a Varian EM 360L spectrometer in deuteriochloroform using tetraethylsilane as internal standard. The mass spectra were run on a VG ZAB-2F instrument operating at 70 eV (200  $\mu$ A). Microanalysis for CHN were carried on a Carlo Erba model 1106 Elemental Analyzer. Phase-transfer reactions in presence of catalysts **1a-f** were carried out as previously described by Montanari [16]. The glc analyses were performed on a Carlo Erba model HRGC 5300 flame ionization instrument (SE 30, 5% over Chromosorb).

General Procedure for the Synthesis of **1c-e**.

A procedure described in literature [15] was followed.

The glycol and diacyl chloride, each dissolved in 200 ml of benzene were slowly added simultaneously to 600 ml of stirring benzene at 50-60°. The mixture was stirred under a nitrogen atmosphere at 50-60° for at least two days. After the reaction was stopped, benzene was removed under vacuum. The crude product was then purified by column chromatography on silica gel using hexane-chloroform (3:1) as eluent. Following this general method, compounds **1c-e** were prepared.

1,4,7,10,13-Pentaoxacycloeicosane-14,20-dione (**1c**).

Tetraethyleneglycol (6.4 g, 0.033 mole) and pimeloyl chloride (6.5 g, 0.033 mole) were used. The product (33%), a viscous liquid,  $n_D^{25}$  1.4737, exhibited the following spectra: ir (film): 1740  $cm^{-1}$ ; nmr (deuteriochloroform):  $\delta$  1.06-1.76 (m, 6H,  $CH_2$ ), 2.23 (t, 4H,  $CH_2-CO$ ), 3.56 (s, 12H,  $CH_2-O-CH_2$ ), 4.13 (t, 4H,  $COOCH_2$ ); ms: (m/e) 319 (1), 318 (0.05).

Anal. Calcd. for  $C_{15}H_{26}O_5$ : C, 56.59; H, 8.23. Found: C, 56.61; H, 8.24.

1,4,7,10,13-Pentaoxacyclodocosane-14,22-dione (**1d**).

This compound was prepared as described for **1c** starting with tetra-

ethyleneglycol (6.4 g, 0.033 mole) and azeloyl chloride (7.4 g, 0.033 mole) to give **1d**, yield 33%,  $n_D^{25}$  1.4723; ir (film): 1730  $\text{cm}^{-1}$ ; nmr (deuteriochloroform):  $\delta$  1.1-1.71 (m, 10H,  $\text{CH}_2$ ), 2.33 (t, 4H,  $\text{CH}_2\text{-CO}$ ), 3.58 (s, 12H,  $\text{CH}_2\text{-O-CH}_2$ ), 4.16 (t, 4H,  $\text{COOCH}_2$ ); ms: (m/e) 347 (0.3), 346 (0.05).

Anal. Calcd. for  $\text{C}_{17}\text{H}_{30}\text{O}_7$ : C, 58.94; H, 8.73. Found: C, 58.91; H, 8.71.

1,4,7,10,13-Pentaoxacyclotricosane-14,23-dione (**1e**).

This compound was prepared as described for **1c** starting with tetraethyleneglycol (6.4 g, 0.033 mole) and sebacoyl chloride (7.88 g, 0.033 mole), to give **1e**, yield 31%,  $n_D^{25}$  1.4693; ir (film): 1730  $\text{cm}^{-1}$ ; nmr (deuteriochloroform):  $\delta$  1.1-1.71 (m, 12H,  $\text{CH}_2$ ), 2.26 (t, 4H,  $\text{CH}_2\text{-CO}$ ), 3.60 (s, 12H,  $\text{CH}_2\text{-O-CH}_2$ ), 4.16 (t, 4H,  $\text{COOCH}_2$ ); ms: (m/e) 361 (1), 360 (0.05).

Anal. Calcd. for  $\text{C}_{18}\text{H}_{32}\text{O}_7$ : C, 59.98; H, 8.85. Found: C, 60.02; H, 8.94.

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