

Synthesis and chemical properties of polyacetylenic derivatives of benzo- and dibenzo- crown ethers

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Dedicated to Professor Boris A. Trofimov, for his 65th birthday
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Abstract

4',5'-Diethynylbenzo-15-crown-5- (**6**), 4',5'(5'')-diethynyldibenzo-18-crown-6 (**10**, **11**) and 4',5',4'',5''-tetraethynyl-dibenzo-18-crown-6 (**12**) ethers were synthesized by cross-coupling of the corresponding di- and tetra- iodides (**1–4**) with trimethylsilylacetylene (**5a**) or 2-methylbut-3-yn-2-ol (**5c**) followed by treatment of the resulting products with alkali. The Mannich reaction with the di- and tetraethynyl derivatives was also carried out.

Keywords: Benzocrown ethers, alkynes, cross-coupling reaction, polyethynylbenzocrown ethers, aminoalkylation, the retro-Favorsky reaction, the Mannich reaction, homogeneous catalysis

Introduction

The crown ethers are very attractive compounds for analytical and coordination chemistry as well as for pharmaceutical applications because of their ability to bind cations selectively.¹ However, the chemistry of acetylenic derivatives of the crown ethers remains poorly studied owing to the limited synthetic approaches to these compounds. Only a few publications are devoted to the synthesis of acetylenylbenzocrown ethers by cross-coupling of iodoarenes with terminal acetylenes,^{2,3} whereas the preparation of polyethynyl-benzo-crown ethers is not described at all.

Moreover, we have found some important details, both when we tried to obtain even simple monoethynylbenzocrown ethers and when we carried out the Mannich reaction⁴ with them. For the above reasons, and the fact that the introduction of several acetylenic groups – especially terminal ones – into the crown ether molecules increases their synthetic and application potential through increasing their reactivity, we undertook investigations to develop methods of synthesis

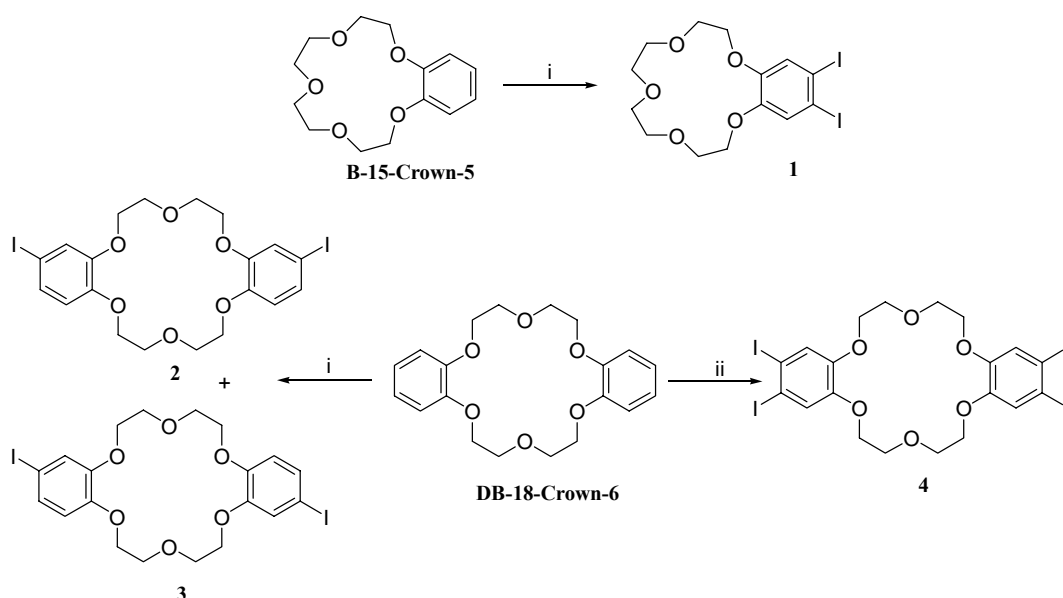
of poly(ethynyl)benzocrown ethers and to study their behavior in the cross-coupling and Mannich reactions.

Results and Discussion

The cross-coupling of aryl halides with terminal acetylenes (the Sonogashira reaction) has become a general method for the preparation of arylalkynes,^{3,5} and we therefore used this approach to obtain the target polyacetylenic compounds.

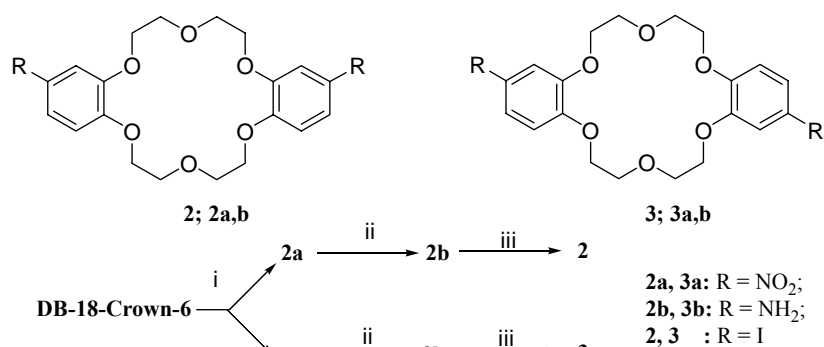
Since 1975, when Sonogashira *et al.*⁵ discovered the catalytic system (PdCl₂(PPh₃)₂-CuI-Et₂NH) for the cross-coupling of 1-alkynes with *sp*²-halides, this method is considered the best one for the preparation of various aryl- and heterylacetylene derivatives. However, the Pd/Cu-catalyzed cross-coupling of 1-alkynes with iodoarenes having electron-donor substituents (NR₂, OR) is accompanied by homo-coupling of the alkynes and the reductive de-iodination of iodoarenes. Sometimes such side-reactions become the only ones.⁶ The replacement of iodine atoms by acetylenic groups in the weakly reactive polyhalobenzocrown ethers (owing to the deactivating influence of several alkoxy groups possessing +M effects) has not been attempted.

We have investigated the possibility of using the cross-coupling of poly-iodocrown ethers to introduce several acetylenic groups into a crown ether molecule. The starting diiodobenzocrown ethers **1–3** were synthesized by direct oxidative iodination of the corresponding ethers in an I₂-HIO₃-H₂SO₄ system⁷ at 50–55 °C (yield 50–80%) (Scheme 1). Under the above conditions, for dibenzo-18-crown-6 (2 mol of iodination mixture / mol of starting compound) a mixture of *cis*- (**2**) and *trans*- (**3**) isomers was obtained in a total yield of 83%. Tetraiododibenzocrown ether **4** (60%) was obtained from dibenzo-18-crown-6 and I₂, NaIO₄, and H₂SO₄ in dioxane under reflux.



Scheme 1. i. I_2 -HIO₃-H₂SO₄, acetic acid; ii. I_2 -HIO₃-H₂SO₄, dioxane.

The synthesis of individual *cis*- (**2**) and *trans*- (**3**) isomers was realized from the corresponding dinitrodibenzo-18-crown ethers (**2a**, **3a**) (Scheme 2). Nitration of dibenzo-18-crown ether by nitric acid mixed with acetic acid in chloroform resulted in a mixture of *cis*- and *trans*- dinitrodibenzo-18-crown ethers, which were separated by recrystallization from DMF.⁸ Reduction of the nitro derivatives by hydrazine hydrate in the presence of 4% Pd/C in boiling ethanol^{9,10} led to the *cis*-amino- (**2b**, 63%), and *trans*-amino- crown ether (**3b**, 87%). Denitration of the isomers (**2b**) and (**3b**) was carried out in diluted H₂SO₄ followed by KI addition in the presence of freshly prepared Cu(0), as described for *p*-iodo-phenols.¹¹ The *cis*-iodocrown ether (**2**) and *trans*- isomer (**3**) were formed in 32% and 42% yields, respectively.

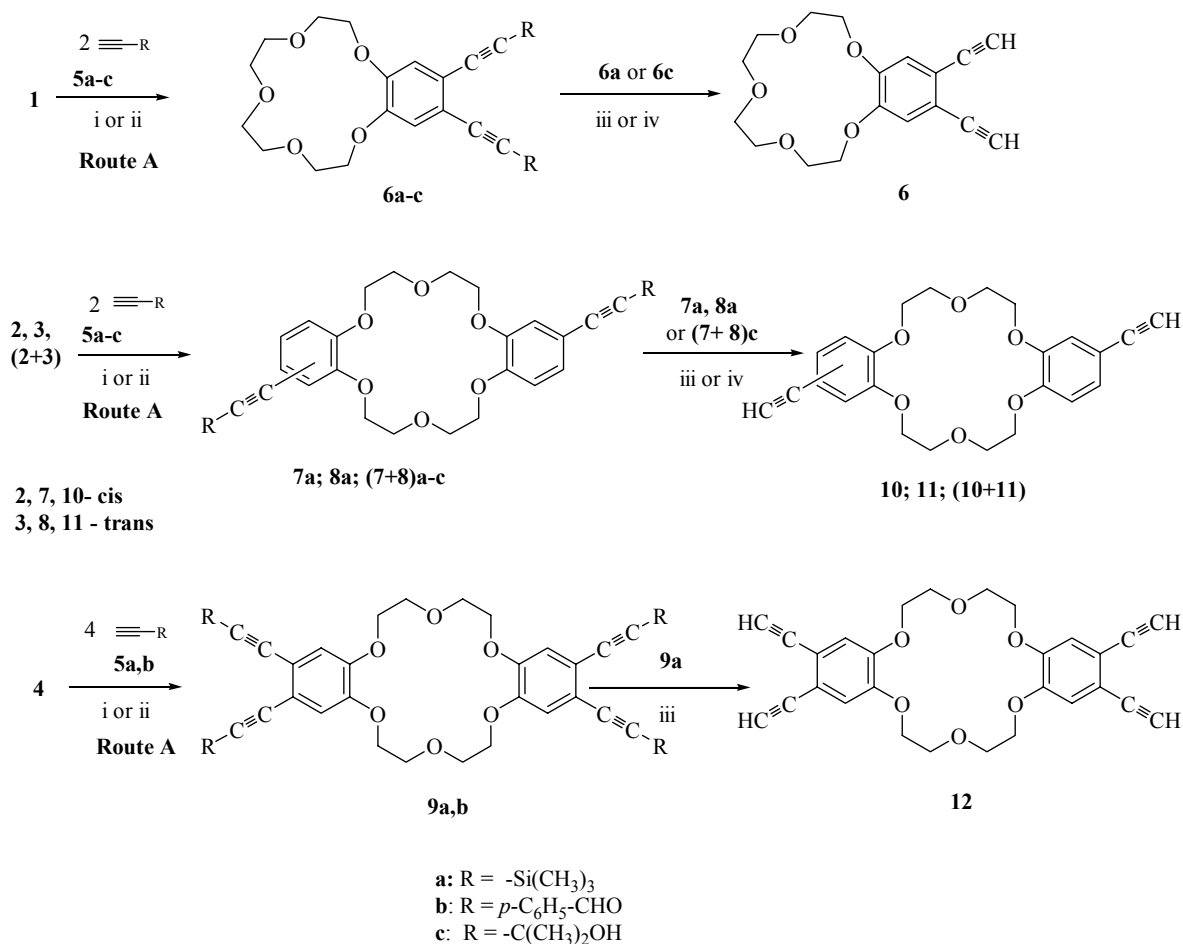


Scheme 2. i. HNO₃, CH₃COOH, recrystallization from DMF. ii. NH₂NH₂, Pd/C, C₂H₅OH, iii. NaNO₂, 5% H₂SO₄, KI, Cu⁰, 0°C.

We used trimethylsilylacetylene (**5a**), *p*-ethynylbenzaldehyde (**5b**) and 2-methylbut-3-yn-2-ol (**5c**) as acetylenic components in the cross-coupling^{5,12} of polyiodocrown ethers (**1–4**). A special interest in acetylenylbenzocrown ethers bearing formyl groups was caused by the possibility of their forming stable nitronyl-nitroxide radicals, since they are precursors of 2-imidazoline. We have previously shown that acetylenic derivatives of heterarylnitronyl-nitroxides possess very interesting optical and magnetic properties.¹³ 2-Methylbut-3-yn-2-ol (**5c**) and trimethylsilylacetylene (**5a**) allowed the synthesis of terminal acetylenes, which are very promising key compounds, owing to their unusually high CH- acidity that could possibly be used both for functionalizing and building C–C bonds.

Usually, condensation of aryl iodides with 1-alkynes has been carried out in the presence of PdCl₂(PPh₃)₂, CuI, and Et₂NH at 70–75 °C under argon. These reaction conditions proved to be inefficient in cross-coupling of iodides with *p*-ethynylbenzaldehyde (**5b**). In our reaction, a finely dispersed black precipitate, apparently of metallic palladium, was obtained, formed as a result of complex decomposition. Previously,¹⁴ the attempt to conduct the cross-coupling of isomeric

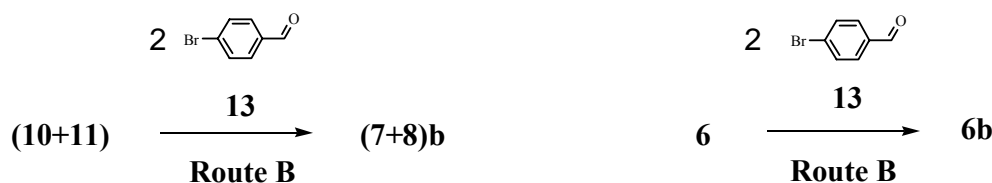
bromobenzaldehydes with trimethylsilylacetylene in the presence of catalytic amounts of Pd(OAc)₂ and PPh₃ was reported: however, iodide **1** did not react with alkyne **5b** under these conditions. It is known³ that activation of the alkynyl component with the addition of CuI (for aryl halides with terminal acetylenes) leads to a considerable increase in cross-coupling. We have found that the reaction of **1** with **5b** in the system involving Pd(OAc)₂, PPh₃, and NEt₃ in the presence of CuI afforded the ether **6b** in 75% yield. The diethynyl derivative **6** was prepared from compound **6a** by removing the trimethylsilyl group.



Scheme 3. i. PdCl₂(PPh₃)₂, CuI, NEt₃. ii. Pd(OAc)₂, CuI, NEt₃, 65–70 °C. iii. KOH (K₂CO₃), methanol, 20 °C. iv. KOH, benzene, 80 °C, or KOH, toluene, 110 °C.

For the synthesis of poly(formylacetylenyl) crown ethers **6b**, **(7+8)b**, **9b** we proposed a scheme involving cross-coupling of the corresponding diiodo derivatives (**1**, **2+3**, **4**) with *p*-ethynyl-benzaldehyde (**5b**) (**route A**) or cross-coupling of ethynylbenzocrown ethers (**6**, **10+11**) with *p*-bromobenzaldehyde **13** (**route B**) in the presence of Pd(OAc)₂, PPh₃, CuI and NEt₃ in

C_6H_6 at 40–80 °C. The yields of the target compounds (7+8)b, 6b, were 50–70%. One should note that the reaction duration and the yields of the products were almost identical in both routes.



Scheme 4. i. Pd(OAc)₂, CuI, NEt₃, 65–70 °C.

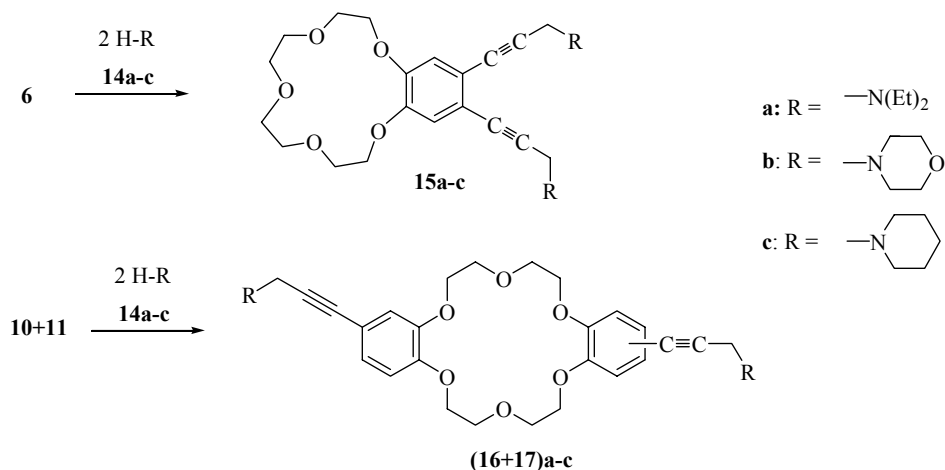
The interaction of dihalobenzocrown ethers (1, 2+3) with 2-methylbut-3-yn-2-ol (5c) in the presence of PdCl₂(PPh₃)₂ (or Pd(OAc)₂ + PPh₃), CuI and NEt₃ led to acetylenic alcohols (6c) and (7+8)c in 60–90% yields. Since cross-coupling of the tetra-iodide 4 with butynol (5c) under these conditions was accompanied by their resinification we used trimethylsilylacetylene (5a) as acetylenic component for introduction of four ethynyl groups into benzo-crown ring. The yield of tetrakis-acetylenic derivative 9a was 30%.

The replacement of the iodine atom in (1, 2+3) by the acetylenic moiety of the tertiary acetylenic alcohol 5c proceeded smoothly at 75–80 °C in the catalytic system PdCl₂(PPh₃)₂-CuI-Et₃N; the yield of (6c) and (7+8)c was 60–90%. A mixture of diiodocrown ether, terminal acetylene, PdCl₂(PPh₃)₂, CuI, in triethylamine was heated for 2–5 h at 75–80 °C under argon.

A usual way for ethynyl-arene preparations involved the cleavage of the tertiary acetylenic alcohols or the trimethylsilylacetylene derivatives by treatment with a catalytic amount of alkali. But earlier⁴ we discovered a specific cleavage “crown-effect” for mono-acetylenic alcohols of benzo-15-crown-5 ether and benzo-18-crown-6 ether that required an extra equimolar amount of KOH, over that used with the corresponding benzo-12-crown-4-ether derivative. Our investigation confirmed the reverse-Favorsky reaction for diacetylenic alcohols (6c) and (7+8)c that could be realized only in the presence of the extra equimolar amount of KOH. Ethynyl crown ethers (6, 10+11) were obtained by Retro-Favorsky reaction. A mixture of tertiary acetylenic alcohols (6c) and (7+8)c and powdered KOH was heated at reflux in dry toluene during 2–4 h, the yields of ethynyl crown ethers (6, 10+11) were 25–30%. Ethynylbenzocrown ethers could also be obtained in another way. For example, the reaction of iodobenzocrown ethers 1–4 with trimethylsilylacetylene 5a led to disubstituted acetylenes (6–9)a in 70–90% yields. Treatment of (6–9)a with KOH or K₂CO₃ in methanol at room temperature resulted in 6, 10–12 in 50–60% yields.

The ethynylbenzocrown ethers did not undergo a Mannich reaction that was carried in the presence¹⁵ of copper(I) salts. It is known¹ that the crown ethers are able to form complexes not only with appropriately sized cations (K⁺-crown-6), but also with the large ones in a “sandwich” type complex. We found⁴ unusual behavior of ethynylcrown ethers in these conditions.¹⁵

Taking into account the high biological activity of compounds having a propargylamino fragment ($\text{N-CH}_2\text{-C}\equiv\text{C}$), we carried out the aminoalkylation reaction on the obtained alkynes (**6**, **10+11**).



Scheme 5. i. $(\text{CH}_2\text{O})_x$, amine (**14a-c**), $\text{Cu}(\text{OAc})_2$, 30% H_2SO_4 , dioxane, 80 °C.

The typical procedure for aminoalkylation of ethynylarenes involved interaction of secondary amines with paraformaldehyde under reflux in dioxane in the presence of CuCl . To avoid the problems we found earlier for mono-ethynylcrown ethers⁴ for the Mannich condensation, the aminoalkylation was carried out in the presence of $\text{Cu}(\text{OAc})_2$ and 30% sulfuric acid.

Aminopropargylcrown ethers **15a-c**, **(16+17)a-c** were obtained by the condensation of alkynes (**6**, **10+11**) with paraformaldehyde and secondary amines **14a-c** in the presence of catalytic amounts of $\text{Cu}(\text{OAc})_2$ under reflux in dioxane (1.5–2 h). Yields of the Mannich bases were 70–80% and depended on the reaction conditions and the nature of the starting amines.

The IR and NMR spectra of **2** and **3**; **7a** and **8a**; **10** and **11** had barely perceptible differences. From reference data for nitro-^{8,10,16,17} and amino derivatives^{10,18} [**2a**, 203–205°C (200–201°C),¹⁰ **3a**, 243–247°C (247–252°C),¹⁶ **2b**, 179–181°C (180–182°C), **3b**, 194–197°C (199–203°C)¹⁸] we supposed the compounds with lower melting points to be the *trans*- isomers (iodo- and ethynyl derivatives), and *vice versa* for the trimethylsilyl derivatives (Table).

Conclusions

In summary, we have established that Pd–Cu- catalyzed cross-coupling of polyiodobenzo- and dibenzo- crown ethers with terminal acetylenes is a convenient method for the introduction of several acetylenic groups into one molecule of the crown ether. The ease of both the introduction and elimination of the protective silyl and alcohol groups makes this procedure attractive for

preparing polyfunctional synthons, such as polyethynylbenzocrown ethers. A series of the Mannich bases has been synthesized by aminoalkylation of ethynyl derivatives.

Experimental Section

General Procedures. Melting points were determined with a hot-stage microscope. Column chromatography was performed on silica gel (Merck 60, 70–230 mesh). The R_f values were measured on aluminum-backed TLC plates of silica gel Silufol UV-254, with the indicated eluent. NMR spectra were recorded on a “Bruker Avance 300” spectrometer at 25 °C. ^1H NMR chemical shifts (δ in ppm) were given from internal CHCl_3 (7.26) or $\text{DMSO-}d_6$ (2.5) standards. Coupling constants (J in Hz) were accurate to ± 0.2 Hz for ^1H . Mass spectra (HRMS) at 70 eV using the electron impact mode were recorded on a Finnigan SSQ–710. The IR spectra were recorded in KBr pellets on a “Bruker IFS 66” instrument.

p-Bromobenzaldehyde,¹⁹ and *p*-ethynylbenzaldehyde²⁰ were synthesized according to known procedures. $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$, $\text{Pd}(\text{OAc})_2$, NaNO_2 , NaIO_4 , KI , I_2 , CuI , PPh_3 , 2-methylbut-3-yn-2-ol, and ethynyltrimethylsilane (“Aldrich”) were commercially available reactants. All the organic solvents were of analytical quality. **See Table on page 231.**

3,4-Diiodobenzo-15-crown-5 (1). A mixture of iodine (2.0 g, 8.2 mmol) and HIO_3 (1.5 g, 8.5 mmol) was slowly added by portions to a stirred solution of benzo-15-crown-5 (2.7 g, 10.1 mmol) in a mixture of 80% acetic acid (40 mL) and 30% sulfuric acid (5 mL). The reaction mixture was stirred to its discoloration during 2 h at 50–55 °C, and then cold water (300 mL) was added. The solution was washed with 30% Na_2SO_3 aq. and extracted with CHCl_3 (3x100 mL), the organic layer was dried over Na_2SO_4 , filtered through a SiO_2 bed (height/diameter of the column: 2.5x2 cm). The solvent was removed *in vacuo* and the residue recrystallized from a mixture of benzene-hexane. The yield of **1** was 3.9 g (75%), mp 97–99 °C. ^1H NMR data: δ (CDCl_3) 3.67–3.75 (8H, m, 2 CH_2OCH_2), 3.76–3.85 (4H, m, 2 $\text{ArOCH}_2\text{CH}_2$), 4.10–4.20 (4H, m, 2 $\text{ArOCH}_2\text{CH}_2$), 6.91 (2H, s, 2-H, 5-H). Anal. Calcd. for $\text{C}_{14}\text{H}_{18}\text{I}_2\text{O}_5$ (520.10): C, 32.33; H, 3.49; I, 48.80. Found: C, 32.52; H, 3.27%.

3,3'(4')-Diiododibenzo-18-crown-6 (2+3). A mixture of iodine (2.1 g, 8.4 mmol) and HIO_3 (1.5 g, 8.5 mmol) was slowly added in portions to a stirred solution of dibenzo-18-crown-6 (4.2 g, 10 mmol) in a mixture of 80% acetic acid (40 mL) and 30% sulfuric acid (5 mL). The reaction mixture was stirred to its discoloration during 2 h at 50–55 °C, and then cold water (300 mL) was added. The solution was washed with 30% Na_2SO_3 aq. and extracted with CHCl_3 (3x100 mL), and the organic layer dried on Na_2SO_4 , filtered through a SiO_2 bed (2.5x2 cm). The solvent was removed *in vacuo* and the residue was recrystallized from toluene. The yield of mixture of *cis*- and *trans*- isomers (**2+3**) was 5.6 g (83%), mp 176–180 °C; ^1H NMR: δ (CDCl_3) 3.94–4.07 (8H, m, 2 CH_2OCH_2), 4.09–4.22 (8H, m, 4 ArOCH_2), 6.62 (2H, d, 4-H, 12(15)-H, $^2J =$

8.1 Hz), 7.13 (2H, c, 1-H, 15(12)-H), 7.21 (2H, d, 3-H, 13(14)-H, $^2J = 8.1$ Hz). Anal. Calcd. for $C_{20}H_{22}I_2O_6$ (612.19): C, 39.24; H, 3.62; I, 41.46. Found: C, 39.72; H, 3.39%.

3,4,3',4'-Tetraiododibenzo-18-crown 6 (4). A mixture of iodine (4.3 g, 16.9 mmol) and HIO_3 (2.1 g, 11.9 mmol) was slowly added by portions to stirred solution of dibenzo-18-crown-6 (4.2 g, 10 mmol) in a mixture of dioxane (40 mL) and 30% sulfuric acid (10 mL). The reaction mixture was stirred to its discoloration during 2 h at 50–55 °C, and then cold water (300 mL) was added. The resulting brown precipitate was filtered, washed with water (20 mL), dried in air, and recrystallized from DMF. The yield of the compound **4** was 2.9 g (63%); mp 237–239 °C. 1H NMR data: δ (CD_3) $_2SO$ 3.78–3.85 (8H, m, 2 CH_2OCH_2), 3.98–4.05 (8H, m, 4 $ArOCH_2$), 7.31 (4H, s, 2-H, 5-H, 2'-H, 15-H). Anal. Calcd. for $C_{20}H_{20}I_4O_6$ (863.9): C, 27.80; H, 2.33; I, 58.75. Found: C, 27.62; H, 2.29%.

3,3'-Diiododibenzo-18-crown-6 (2). Amine **2b** (1.6 g, 4.1 mmol) in a mixture of water (10 mL), ice (10 g) and H_2SO_4 (2 mL) was denitrated by a cold solution of $NaNO_2$ (0.7 g, 10.1 mmol in 5 mL H_2O) at 0 +5 °C. Sulfuric acid (5 mL) was added after 20 min and the solution obtained was slowly added to a cold solution of aqueous KI (2.0 g, 12 mmol in 5 mL) containing Cu^0 (0.5 g, 7.8 mmol), and the reaction mass carefully heated on a hot-water bath (65–70 °C) until nitrogen gas liberation stopped. The solution was extracted with $CHCl_3$ (3x100 mL), washed with water, and then 30% Na_2SO_3 aq., and the organic layer dried over Na_2SO_4 , and filtered through a SiO_2 -bed (2.5x2 cm). The solvent was removed *in vacuo* and the residue was recrystallized from benzene. The yield of compound **2** was 0.8 g (32%), mp 231–232 °C. Anal. Calcd. for $C_{20}H_{22}I_2O_6$ (612.19): C, 39.24; H, 3.62; I, 41.46. Found: C, 39.37; H, 3.69%. The NMR 1H and IR spectra are given in the Table.

3,4'-Diiododibenzo-18-crown-6 (3). According to the procedure above, the denitration of amine **3b** (1.2 g, 3.9 mmol) was carried out by using $NaNO_2$ (0.6 g, 8.7 mmol), KI (1.6 g, 9.6 mmol) and Cu^0 (0.5 g, 7.8 mmol); the purification by column chromatography resulted in 0.8 g (42%) of compound **3**, mp 189–191 °C (from benzene–hexane). Anal. Calcd. for $C_{20}H_{22}I_2O_6$ (612.19): C, 39.24; H, 3.62; I, 41.46. Found: C, 39.37; H, 3.69; I, 41.73%. The 1H -NMR and IR spectra are given in the Table.

3,4-bis-(Trimethylsilyl ethynyl)benzo-15-crown-5 (6a). A mixture of iodide (**1**) (0.5, 1 mmol) and the acetylene **5a** (0.4 mL, 2.8 mmol) in the presence of $PdCl_2(PPh_3)_2$ (15 mg, 0.021 mmol) and CuI (7.5 mg, 0.075 mmol) in Et_3N (1 mL) and benzene (10 mL) was stirred at 75–80 °C for 0.5 h. Finally, the mixture was filtered through a SiO_2 column (2.5x2 cm) and evaporated *in vacuo*, and the residue was recrystallized from a mixture of benzene–hexane. The yield of compound **6a** was 0.36 g (87.7%), mp 97–99 °C. IR (KBr): ν [cm^{-1}] 2152 ($C\equiv C$). 1H NMR data: δ ($CDCl_3$) 0.26 (18 H, s, 2 $Si(CH_3)_3$); 3.83 (8 H, s, 4 OCH_2); 3.86–3.93 (4 H, m, 2 $ArOCH_2CH_2$); 4.08–4.17 (4 H, s, 2 $ArOCH_2CH_2$); 6.91 (2 H, s, 2-H, 5-H). MS, m/z , %: 460.0 $[M]^+$ (100), 372.0 (9), 328.0 (18), 312.9 (38), 73.0 (54). Calcd. for $C_{24}H_{36}O_5Si_2$ $M = 460.2161$. Found: m/z 460.2100 $[M]^+$.

3,3'(4')-bis-(Trimethylsilyl ethynyl)dibenzo-18-crown-6 (7+8)a. From the mixture of iodides (**2+3**) (2.5 g, 4.2 mmol) and the acetylene **5a** (1.3 mL, 9.3 mmol) in the presence of $PdCl_2(PPh_3)_2$

(90 mg, 0.129 mmol), CuI (45 mg, 0.45 mmol), a mixture of the compounds (7+8)a, 1.6 g (69.6%), m.p. 181–184.5 °C was synthesized as above. IR (KBr): ν [cm^{-1}] 2143 (C \equiv C). ^1H NMR: δ (CDCl_3) 0.28 (18 H, s, 2 Si(CH $_3$) $_3$), 4.03–4.05 (8 H, m, 2 CH $_2$ OCH $_2$); 4.17–4.19 (8 H, m, 4 ArOCH $_2$); 6.78 (2 H, d, 5-H, 5'(2')-H, $J = 8.2$), 6.98 (2 H, d, 2-H, 2'(5')-H, $J = 2.5$), 7.08 (2 H, dd, 4-H, 4'(3')-H, $^1J = 8.2$, $^2J = 2.5$). Anal. Calcd. for C $_{30}$ H $_{40}$ O $_6$ Si $_2$ (552.81):C, 65.18; H, 7.29. Found: C, 65.21; H, 7.09%.

3,3'-bis-(Trimethylsilylethynyl)dibenzo-18-crown-6 (7a). A mixture of iodide (2) (0.63g, 1 mmol), acetylene 5a (0.4 mL, 3.1 mmol) in the presence of PdCl $_2$ (PPh $_3$) $_2$ (30 mg, 0.043 mmol) and CuI (15 mg, 0.15 mmol) in Et $_3$ N (2 mL) and benzene (10 mL) was stirred at 75–80 °C for 0.25 h. Finally, the mixture was filtered through a SiO $_2$ column (2.5x2 cm) and evaporated *in vacuo*, and the residue was recrystallized from a mixture of benzene–hexane. The yield of compound 7a was 0.2 g (40%), mp 176–178 °C. Anal. Calcd. for C $_{30}$ H $_{40}$ O $_6$ Si $_2$ (552.81):C, 65.18; H, 7.29. Found: C, 65.31; H, 7.63%. The ^1H -NMR and IR spectra are given in the Table.

3,4'-bis-(Trimethylsilylethynyl)dibenzo-18-crown-6 (8a). A mixture of iodide (3) (0.65 g, 1 mmol) and the acetylene 5a (0.4 mL, 3.1 mmol) in the presence of PdCl $_2$ (PPh $_3$) $_2$ (30 mg, 0.043 mmol) and CuI (15 mg, 0.15 mmol) in Et $_3$ N (2 mL) and benzene (10 mL) was stirred at 75–80 °C for 0.25 h. Finally, the mixture was filtered through a SiO $_2$ column (2.5x2 cm) and evaporated *in vacuo*, and the residue was recrystallized from a mixture of benzene–hexane. The yield of compound 8a was 0.24 g (41%), mp 191–193 °C. Anal. Calcd. for C $_{30}$ H $_{40}$ O $_6$ Si $_2$ (552.81):C, 65.18; H, 7.29. Found: C, 64.91; H, 7.55%. The ^1H -NMR and IR spectra are given in the Table.

3,4,3',4'-tetrakis-(Trimethylsilylethynyl)dibenzo-18-crown-6 (9a). A mixture of the iodide (4) (0.5 g, 0.5 mmol) and the acetylene 5a (0.4 mL, 3.1 mmol) in the presence of PdCl $_2$ (PPh $_3$) $_2$ (30 mg, 0.043 mmol) and CuI (15 mg, 0.15 mmol) in Et $_3$ N (2 mL) and benzene (10 mL) was stirred at 75–80 °C for 0.25 h. Finally, the mixture was filtered through a SiO $_2$ column (2.5x2 cm) and evaporated under reduced pressure. The residue was recrystallized from benzene–hexane mixture. The yield of compound 9a was 0.13 g (40.2%), mp 98–100 °C. IR (KBr): ν [cm^{-1}] 2154 (C \equiv C). ^1H NMR data: δ (CDCl_3) 0.31 (36 H, s, 4 Si(CH $_3$) $_3$), 4.01–4.03 (8 H, m, 2 CH $_2$ OCH $_2$); 4.17–4.18 (8 H, m, 4 ArOCH $_2$); 6.91 (4-H, s, 2-H, 5-H, 5'-H, 2'-H). Anal. Calcd. for C $_{40}$ H $_{56}$ O $_6$ Si $_4$ (745.21):C, 64.47; H, 7.57. Found: C, 64.11; H, 7.29%.

3,4-bis-(*p*-Ethynylbenzaldehyde)benzo-15-crown-5 (6b). Route A (Scheme 3). A mixture of iodide (1) (0.9 g, 1.7 mmol), acetylene 5b (0.4 g, 3.1 mmol) in the presence of Pd(OAc) $_2$ (20 mg, 0.089 mmol) and CuI (15 mg, 0.15 mmol), PPh $_3$ (60 mg, 0.228 mmol) in Et $_3$ N (7 mL) and benzene (15 mL) was stirred at 75–80 °C for 0.25 h. Finally, the mixture was filtered through a SiO $_2$ column (2.5x2 cm) and evaporated *in vacuo*, and the residue was purified by column chromatography and then recrystallized from benzene–hexane mixture. The yield of compound 6b was 0.69 g (76.7%).

Route B (Scheme 4). A mixture of the acetylene (6) (0.1 g, 0.3 mmol), 4-bromobenzaldehyde 13 (0.14 g, 0.7 mmol) in presence of Pd(OAc) $_2$ (10 mg, 0.044 mmol) and CuI (5 mg, 0.026 mmol), PPh $_3$ (30 mg, 0.114 mmol) in Et $_3$ N (2 mL) and benzene (10 mL) was stirred at 75–80 °C for 0.25

h. Finally, the mixture was filtered through a SiO₂ column (2.5x2 cm) and evaporated *in vacuo*, and the residue was purified by column chromatography and then recrystallized from benzene. The yield of compound **6b** was 0.08 g (62.5%); mp 156–157 °C. IR (KBr): ν [cm⁻¹] 1697 (C=O), 2204 (C≡C). ¹H-NMR data: δ (CDCl₃) 3.69 (8 H, s, 4 OCH₂); 3.86–3.95 (4 H, m, 2 ArOCH₂CH₂); 4.15–4.22 (4 H, m, 2 ArOCH₂CH₂); 7.08 (2 H, s, 2-H, 5-H), 7.69 (4 H, d, 2,2'-H, 2,6'-H, *J* = 8.2), 7.89 (4 H, d, 2,3'-H, 2,5'-H, *J* = 8.2), 10.05 (2 H, s, CHO). Anal. Calcd. for C₃₂H₂₈O₇ (524.56): C, 73.27; H, 5.38. Found: C, 73.14; H, 5.45%.

3,3'(4')-bis-(*p*-Ethynylbenzaldehyde)dibenzo-18-crown-6 (7+8)b. Route A (Scheme 3). The compounds mixture (7+8)b, 0.79 g (52.3%) was prepared from a mixture of the compounds (2+3) (1.5 g, 2.4 mmol), *p*-ethynylbenzaldehyde **5b** (0.78 g, 5.9 mmol) in the presence of Pd(OAc)₂ (20 mg, 0.089 mmol), CuI (10 mg, 0.0520 mmol), PPh₃ (60 mg, 0.228 mmol) in NEt₃ (10 mL) and benzene (15 mL).

Route B (Scheme 4). The mixture of (7+8)b 0.9 g (52.9%), mp 147–154 (toluene) was prepared from a mixture of the compounds (10+11) (1.1 g, 2.7 mmol), *p*-bromobenzaldehyde **13** (1.2 g, 6.7 mmol) in the presence of Pd(OAc)₂ (20 mg, 0.089 mmol), CuI (10 mg, 0.052 mmol), PPh₃ (60 mg, 0.228 mmol) in NEt₃ (10 mL) and benzene (15 mL). IR (KBr): ν [cm⁻¹] 1653 (C=O), 2201 (C≡C). ¹H NMR data: δ (CDCl₃) 3.91–3.94 (8 H, m, 2 CH₂OCH₂); 4.16–4.19 (8 H, m, 4 ArOCH₂); 7.02 (2 H, d, 5-H, 5(2')-H, *J* = 8.4); 7.23 (2 H, s, 2-H, 2'(5')-H); 7.27 (2 H, d, 4-H, 4'(3')-H, *J* = 8.4); 7.65 (4 H, d, 2 2'-H, 2,6'-H, *J* = 8.2); 7.87 (4 H, d, 2,3'-H, 2,5'-H, *J* = 8.2); 10.04 (2 H, s, 2 CHO). Anal. Calcd. for C₃₈H₃₂O₈ (616.66): C, 74.01; H, 5.23. Found: C, 74.21; H, 5.28%.

3,4,3',4'-tetrakis(*p*-Ethynylbenzaldehyde)-18-crown-6 (9b). Route A (Scheme 3). The compound (9b) (0.9 g, 89.1%), mp 223–225 (toluene) was prepared from the compound (4) (1 g, 1.3 mmol), *p*-ethynylbenzaldehyde **5b** (0.9 g, 0.7 mmol) in the presence of Pd(OAc)₂ (20 mg, 0.089 mmol), CuI (10 mg, 0.0520 mmol), PPh₃ (60 mg, 0.228 mmol) in NEt₃ (10 mL) and benzene (15 mL). IR (KBr): ν [cm⁻¹] 1698 (C=O), 2203 (C≡C). ¹H NMR data: δ (CDCl₃) 3.89–3.95 (8 H, m, 2 CH₂OCH₂); 4.17–4.18 (8 H, m, 4 ArOCH₂); 7.28 (4 H, s, 2-H, 5-H, 5'-H, 2'-H); 7.68 (8 H, d, 4,2'-H, 6'-H, *J* = 8.2); 7.88 (8 H, d, 4,3'-H, 5'-H, *J* = 8.2); 10.04 (4 H, s, 4 CHO). Anal. Calcd. for C₅₆H₄₀O₁₀ (872.91): C, 77.05; H, 4.62. Found: C, 77.21; H, 5.28%.

3,4-bis-(3-Hydroxy-3-methylbut-1-ynyl)benzo-15-crown-5 (6c). A mixture of iodide **1** (0.5, 1 mmol), and the acetylene **5c** (0.23 mL, 2.5 mmol) in the presence of PdCl₂(PPh₃)₂ (15 mg, 0.021 mmol) and CuI (7.5 mg, 0.075 mmol) in Et₃N (1 mL) and benzene (15 mL) was stirred at 75–80 °C for 2.5–3 h. Finally, the mixture was filtered through a SiO₂ bed in a column (2.5x2 cm) and evaporated *in vacuo*, and the residue was recrystallized from benzene. The yield of compound **6c** was 0.2 g (48.8%), mp 103–105 °C. IR (KBr): ν [cm⁻¹] 2200 (C≡C); 3222 (br., OH). ¹H NMR data: δ (CD₃)₂SO) 1.18 (12 H, s, 2 C(CH₃)₂); 3.76–3.81 (8 H, m, 4 OCH₂); 3.89–3.95 (4 H, m, 2 ArOCH₂CH₂); 4.10–4.20 (4 H, m, 2 ArOCH₂CH₂); 6.89 (2 H, s, 1-H, 4-H). Anal. Calcd. for C₂₄H₃₂O₇ (432.51): C, 66.65; H, 7.46. Found: C, 66.52; H, 7.39%.

3,3'(4')-bis-(3-Hydroxy-3-methylbut-1-ynyl)dibenzo-18-crown-6 (7+8)c. A mixture of iodides (2+3) (1g, 1.5 mmol), and carbinol **5c** (0.3 mL, 3.3 mmol) in the presence of

$\text{PdCl}_2(\text{PPh}_3)_2$ (30 mg, 0.043 mmol) and CuI (15 mg, 0.15 mmol) in Et_3N (2 mL) and benzene (10 mL) was stirred at 75–80 °C for 2.5–3 h. Finally, the mixture was filtered through a SiO_2 column (2.5x2 cm) and evaporated *in vacuo*, and the residue was recrystallized from mixture of benzene-hexane. The yield of the mixed compounds (**7+8**)**c** was 0.75 g (86.2%), mp 87–91 °C. IR (KBr): ν [cm^{-1}] 2223 ($\text{C}\equiv\text{C}$); 3374 (br., OH). ^1H NMR data: δ (CD_3SO) 1.57 (12 H, s, 2 $\text{C}(\text{CH}_3)_2$); 3.98–4.05 (8 H, m, 4 OCH_2); 4.17–4.18 (4 H, m, 2 $\text{ArOCH}_2\text{CH}_2$); 6.79 (2 H, d, 5-H, 5'(2')-H, $J = 8.2$); 6.93 (2 H, s, 2-H, 2'(5')-H); 7.02 (2 H, d, 4-H, 4'(3')-H, $J = 8.2$). Anal. Calcd. for $\text{C}_{30}\text{H}_{36}\text{O}_8$ (524.60): C, 68.68; H, 6.92. Found: C, 68.6166.52; H, 7.09%.

3,4-Diethynylbenzo-15-crown-5 (6). Procedure iii (Scheme 3). The compound **6a** (0.24 g, 0.5 mmol) was treated with a 10% solution of KOH in methanol (15 mL). The yield of the compound **6** was 0.1 g (60%), mp 109–110 °C. **Procedure iv (Scheme 3).** A mixture of **6c** (0.2 g, 0.48 mmol) and powdered KOH (0.1 g, 1.7 mmol) (20 mL) was boiled in dry benzene for 2.5–3 h. Finally, the mixture was filtered through a SiO_2 column (2.5x2 cm) and evaporated *in vacuo*. The residue was recrystallized from benzene-hexane mixture. The yield of compound **6** was 0.03 g (20%).

IR (KBr): ν [cm^{-1}] 2120 ($\text{C}\equiv\text{C}$); 3219, 3277 ($\text{C}\equiv\text{CH}$). ^1H NMR: δ (CDCl_3) 3.26 (2 H, s, 2 $\text{C}\equiv\text{CH}$); 3.69–3.82 (8 H, m, 4 OCH_2); 3.85–3.97 (4 H, m, 2 $\text{ArOCH}_2\text{CH}_2$); 4.14 (4 H, s, 2 $\text{ArOCH}_2\text{CH}_2$); 6.97 (2 H, s, 2-H, 5-H). MS, m/z , %: 316.20 [M]⁺ (21), 228.2 (11), 184.1 (90), 128.1 (12), 45.1 (10). Calcd. for $\text{C}_{18}\text{H}_{20}\text{O}_5$: $M = 316.13292$. Found: m/z 316.0234 [M]⁺.

3,3'(4')-Diethynyldibenzo-18-crown-6 (10+11) Procedure iii (Scheme 3). The compounds (**7+8**)**a** (0.3 g, 5.4 mmol) were treated with a 10% solution of KOH in methanol (15 mL) at room temperature during 1–1.5 h. The yield of the compounds **10+11** was 0.06 g (27.3%); mp 141–145 °C. **Procedure iv (Scheme 3).** A mixture of (**7+8**)**c** (1.6 g, 3 mmol) and powdered KOH (0.4g, 8 mmole) was boiled in dry toluene (45mL) for 2.5–33 h. Finally, the mixture was filtered through an SiO_2 column (2.5x2 cm) and evaporated *in vacuo*. The residue was purified by column chromatography and recrystallized from benzene-hexane mixture. The yield of compounds (**10+11**) was 0.2g (16.7%).

IR (KBr): ν [cm^{-1}] 2101 ($\text{C}\equiv\text{C}$); 3288 ($\text{C}\equiv\text{CH}$). ^1H NMR: δ (CDCl_3) 3.02 (2 H, s, 2 $\text{C}\equiv\text{CH}$), 4.06–4.17 (8 H, m, 2 CH_2OCH_2); 4.18–4.21 (8 H, m, 4 ArOCH_2); 6.81 (2 H, d, 5-H, 5'(2')-H, $J = 8.5$); 7.01 (2 H, d, 2-H, 2'(5')-H, $J = 2.3$); 7.11 (2 H, dd, 4-H, 4'(3')-H, $^1J = 8.5$, $^2J = 2.3$). Anal. Calcd. for $\text{C}_{24}\text{H}_{24}\text{O}_6$ (408.44):C, 70.57, 5.93. Found: C, 70.81.11; H, 5.87%.

3,3'-Di-ethynyldibenzo-18-crown-6 (10). Procedure iii (Scheme 3). The compound **7a** (0.2 g, 0.36 mmol) was treated with K_2CO_3 (0.15 g, 1 mmol) solution in methanol (7 mL) at room temperature for 1–1.5 h. The yield of the compound **10** was 0.1 g (68%); mp 192–194 °C. Anal. Calcd. for $\text{C}_{24}\text{H}_{24}\text{O}_6$ (408.44):C, 70.57, 5.93. Found: C, 70.24; H, 5.86%. The ^1H NMR and IR spectra are given in the Table.

3,4'-Diethynyldibenzo-18-crown-6 (11). Procedure ii (Scheme 3). The compound **8a** (0.2 g, 0.36 mmol) was treated with K_2CO_3 (0.15 g, 1 mmol) solution in methanol (7 mL) at room temperature for 1–1.5 h. The yield of compound **10** was 0.1 g (68%); mp 171–173 °C. Anal.

Calcd. for $C_{24}H_{24}O_6$ (408.44): C, 70.57, 5.93. Found: C, 70.33; H, 5.69%. The 1H -NMR and IR spectra are given in the Table.

3,4,3',4'-Tetrakis(ethynyl)dibenzo-18-crown-6 (12). Procedure iii (Scheme 3). The compound **9a** (0.15 g, 0.2 mmol) was treated with K_2CO_3 (0.15 g, 1 mmol) solution in methanol (7 mL) at room temperature for 1–1.5 h. The yield of compound **12** was 0.05 g (55%); mp 115–117 °C. IR (KBr): ν [cm^{-1}] 2141 ($C\equiv C$); 3278 ($C\equiv CH$). 1H NMR data: δ ($CDCl_3$) 3.2 (4 H, s, 4 $C\equiv CH$), 4.01–4.03 (8 H, m, 2 CH_2OCH_2); 4.17–4.18 (8 H, m, 4 $ArOCH_2$); 6.95 (4 H, s, 2-H, 5-H, 5'-H, 2'-H). Anal. Calcd. for $C_{28}H_{24}O_6$ (456.49): C, 73.67, H, 5.30. Found: C, 73.80; H, 5.47%.

3,4-bis-(3-Diethylaminoprop-1-ynyl)benzo-15-crown-5 (15a). A mixture of the acetylene (**6**) (0.08 g, 0.25 mmol), $(CHO)_x$ (0.02 g, 0.5 mmol) and diethylamine **14a** (0.06 mL, 0.5 mmol) in the presence of $Cu(OAc)_2$ (50 mg), and 30% H_2SO_4 (0.1 mL) was stirred in an atmosphere of argon under refluxing in dioxane (10 mL) at 75–80 °C for 0.25 h. Finally, the mixture was diluted with water (40 mL) and extracted with $CHCl_3$ (3x15 mL). The organic layer was washed with a 15% solution of NH_4OH , dried under $MgSO_4$, and filtered through a SiO_2 column (2.5x2 cm) and evaporated *in vacuo*. The residue was purified by column chromatography then recrystallized from benzene–hexane mixture. The yield of the compound **15a** was 0.08 g (80%); mp 56–58 °C. IR (KBr): ν [cm^{-1}] 2237 ($C\equiv C$). 1H NMR data: δ ($CDCl_3$) 1.25 (12 H, t, 4 CH_2CH_3 , $J = 6.9$); 2.17 (8 H, q, 4 CH_2CH_3 , $J = 6.9$); 3.75 (4 H, s, 2 $C\equiv CCH_2N$); 3.94–3.89 (8 H, m, 4 OCH_2); 4.01–4.06 (4 H, m, 2 $ArOCH_2CH_2$); 4.14 (4 H, s, 2 $ArOCH_2CH_2$); 6.59 (2 H, s, 1-H, 4-H). Anal. Calcd. for $C_{28}H_{42}N_2O_5$ (486.64): C, 69.10; H, 7.46; N, 5.76. Found: C, 69.58; H, 7.37; N, 5.62%.

3,4-bis-(3-Morpholinoprop-1-ynyl)benzo-15-crown-5 (15b). The compound **15b** 0.07 g (58.3%), mp 93–95 °C (from hexane) was prepared from compound **6** (0.08 g, 0.25 mmol), paraformaldehyde (0.02 g, 0.5 mmol), the morpholine **14b** (0.05 mL, 0.5 mmol), $Cu(OAc)_2$ (50 mg), 30% H_2SO_4 (0.1 mL) in boiling dioxane (10 mL), as above. IR (KBr): ν [cm^{-1}] 2226 ($C\equiv C$). 1H NMR data: δ ($CDCl_3$) 2.53–2.55 (4 H, m, $N(CH_2CH_2)_2O$); 3.16 (4 H, s, 2 $C\equiv CCH_2N$); 3.59–3.62 (16 H, m, 4 OCH_2 , 2 $N(CH_2CH_2)_2O$); 3.65–3.77 (4 H, m, 2 $ArOCH_2CH_2$); 4.04 (4 H, s, 2 $ArOCH_2CH_2$); 6.83 (2 H, s, 2-H, 5-H). Anal. Calcd. for $C_{28}H_{38}N_2O_7$ (514.61): C, 65.35; H, 7.44; N, 5.44. Found: C, 65.78; H, 7.37; N, 5.42%.

3,4-bis-(3-Piperidinoprop-1-ynyl)benzo-15-crown-5 (15c). The compound **15c**, 0.06 g (50%), mp 103–105 °C (from hexane) was prepared from compound **6** (0.08 g, 0.25 mmol), paraformaldehyde (0.02 g, 0.5 mmol), piperidine **14c** (0.05 mL, 0.5 mmol), $Cu(OAc)_2$ (50 mg), 30% H_2SO_4 (0.1 mL) in boiling dioxane (10 mL). IR (KBr): ν [cm^{-1}] 2220 ($C\equiv C$). 1H NMR data: δ ($CDCl_3$) 1.41–1.46 (2 H, m, $(CH_2)_2CH_2(CH_2)_2$); 1.64 (4 H, p, 2 $NCH_2CH_2CH_2$, $J = 6.9$); 2.55 (4 H, t, 2 NCH_2 , $J = 6.9$); 3.44 (2 H, s, $C\equiv CCH_2N$); 3.69–3.82 (8 H, m, 4 OCH_2); 3.85–3.97 (4 H, m, 2 $ArOCH_2CH_2$); 4.14 (4 H, s, 2 $ArOCH_2CH_2$); 6.97 (2 H, 2-H, 5-H). Anal. Calcd. for $C_{30}H_{42}N_2O_5$ (510.66): C, 70.56; H, 8.29; N, 5.49. Found: 70.72; H, 8.09; N, 5.61%.

3,4-bis-(3-Diethylaminoprop-1-ynyl)dibenzo-18-crown-6 (16+17)a. A mixture of the compounds **(16+17)a**, 0.08 g (61.5%), mp 145–149 °C (from benzene–hexane) was obtained from mixture of the compounds **10+11** (0.1 g, 0.2 mmol), paraformaldehyde (0.02 g, 0.5 mmol),

diethylamine **14a** (0.05 mL, 0.5 mmol), Cu(OAc)₂ (50 mg), 30% H₂SO₄ (0.1 mL) in boiling dioxane (10 mL). IR (KBr): ν [cm⁻¹] 2143 (C≡C). ¹H NMR data: δ (CDCl₃) 1.15 (12 H, t, 4 CH₂CH₃, $J = 6.8$); 2.65 (8 H, q, 4 CH₂CH₃, $J = 6.8$); 3.65 (4 H, s, 2 C≡CCH₂N); 4.05–4.06 (8 H, m, 2 CH₂OCH₂); 4.17–4.19 (8 H, m, 4 ArOCH₂); 6.80 (2 H, d, 5-H, 2'(5')-H, $J = 8.4$), 6.95 (2 H, d, 2-H, 5'(2')-H, $J = 2.6$), 7.08 (2 H, dd, 4-H, 4'(3')-H, $^1J = 8.4$, $^2J = 2.6$). Anal. Calcd. for C₃₄H₄₆N₂O₆ (578.74): C, 70.56; H, 8.01; N, 4.84. Found: C, 70.21; H, 8.09; N, 4.53%.

3,3'(4')-bis-(3-Morpholinoprop-1-ynyl)dibenzo-18-crown-6 (16+17)b. The compounds **(16+17)b**, 0.06 g (42.9%), mp 128–132 °C (from benzene) were prepared from the mixture of compound **10+11** (0.1 g, 0.2 mmol), paraformaldehyde (0.02 g, 0.5 mmol), morpholine **14b** (0.05 mL, 0.5 mmol), Cu(OAc)₂ (50 mg), 30% H₂SO₄ (0.1 mL) in boiling dioxane (10 mL). IR (KBr): ν [cm⁻¹] 2155 (C≡C). ¹H NMR data: δ (CDCl₃) 2.68–2.59 (4 H, m, N(CH₂CH₂)₂O); 3.05 (4 H, s, 2 C≡CCH₂N); 4.05–4.06 (16 H, m, 2 CH₂OCH₂, 2 O(CH₂CH₂)₂N); 4.17–4.19 (8 H, m, 4 ArOCH₂); 6.88 (2 H, d, 5-H, 5'(2')-H, $J = 8.4$), 7.10 (2 H, d, 2-H, 2'(5')-H, $J = 2.6$), 7.08 (2 H, dd, 4-H, 4'(3')-H, $J = 8.4$, 2.6). Anal. Calcd. for C₃₄H₄₂N₂O₈ (606.71): C, 66.42; H, 6.98; N, 4.62. Found: C, 66.21; H, 6.09; N, 4.53%.

3,3'(4')-bis-(3-Piperidinoprop-1-ynyl)dibenzo-18-crown-6 (16+17)c. A mixture of the compounds **(16+17)c** 0.07 g (50%), mp 126–130 °C (from benzene–hexane) was prepared from a mixture of the compounds **10+11** (0.1 g, 0.2 mmol), paraformaldehyde (0.02 g, 0.5 mmol), piperidine **14c** (0.05 mL, 0.5 mmol), Cu(OAc)₂ (50 mg), 30% H₂SO₄ (0.1 mL) in boiling dioxane (10 mL). IR (KBr): ν [cm⁻¹] 2210 (C≡C). ¹H NMR data: δ (CDCl₃) 1.42–1.56 (2 H, m, (CH₂)₂CH₂(CH₂)₂); 1.68 (4 H, p, 2 CH₂CH₂(CH₂)₃, $J = 6.9$); 2.59 (4 H, t, 2 NCH₂, $J = 6.9$); 3.49 (4 H, s, 2 C≡CCH₂N); 4.05–4.06 (8 H, m, 2 CH₂OCH₂); 4.17–4.18 (8 H, m, 4 ArOCH₂); 6.79 (2 H, d, 5-H, 5'(2')-H, $J = 8.4$), 6.96 (2 H, d, 2-H, 2'(5')-H, $J = 2.6$), 7.05 (2 H, dd, 4-H, 4'(3')-H, $^1J = 8.4$, $^2J = 2.6$). Anal. Calcd. for C₃₆H₄₆N₂O₆ (602.76): C, 71.73; H, 7.69; N, 4.65. Found: C, 71.42; H, 7.87; N, 4.43%.

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References

1. Hiraoka, M. *Crown Compounds. Their Characteristics and Applications*; Elsevier Scientific Publishing Company: New York, 1982.
2. Abel, E.; Maguire, G.E.M.; Meadows, E.S.; Murillo, O.; Jin, T.; Gokel, G.W. *J. Am. Chem. Soc.* **1997**, *119*, 9061.

3. Brandsma, L.; Vasilevsky, S. F.; Verkrujisse, H. D. *Application of Transition Metal Catalysts in Organic Synthesis*; Springer-Verlag: Berlin, Heidelberg, New York, 1998, 335 p
4. Klyatskaya, S. V.; Tretyakov, E. V.; Vasilevsky S. F. *Russian Chem. Bull., Int. Ed.* **2001**, *50*, 868.
5. Sonogashira, K.; Tohda, Y.; Hagihara, N. *Tetrahedron Lett.* **1975**, *50*, 4467.
6. Tretyakov, E. V.; Knight, D. W.; Vasilevsky, S. F. *J. Chem. Soc., Perkin Trans. 1* **1999**, 3721.
7. Hyde, E. M.; Shaw, B. L.; Shepherd, I. *J. Chem. Soc., Dalton Trans.* **1978**, 1696.
8. Feigenbaum, W. M.; Novel, M. R. H. *J. Polym. Sci. (A-1)* **1971**, *9*, 817.
9. Kotlyar, S. A.; Gorodnyuk, V. P.; Gursky, P. N.; Konsdrat'eva, V. A.; Kryshina, E. V.; Ivanov, O.V. *Methods of the preparation and practical application of nitro- and aminobenzo- crown ethers and their derivatives*; NIITEH: Moscow, 1990, p 50.
10. Shchori, E.; Jagur-Grodzinski, J.; Shporer, M. *J. Am. Chem. Soc.* **1973**, *95*, 3842.
11. Dains, F. B.; Eberly, F. *Org. Synth., Coll.* **1943**, *2*, 355.
12. Dieck, H. A.; Heck, F. P. *Organomet. Chem.* **1975**, *93*, 259.
13. (a) Vasilevsky, S. F. (b) Tretyakov, E. V.; Usov, O. M.; Molin, Y. N.; Fokin, S. V.; Shwedenkov, Y. G.; Ikorskii, V. N.; Romanenko, G. V.; Sagdeev, R. Z.; Ovcharenko, V. I. *Mendeleev Comm.* **1998**, 216. Tretyakov, E. V.; Samoilova, R. I.; Ivanov, Y. V.; Plyusnin, V. F.; Pashchenko, S. V.; Vasilevsky, S. F. *Mendeleev Comm.* **1999**, 92.
14. Austin, W. B.; Bilow, N.; Kelleghan, W. J.; Lau K. S. Y. *J. Org. Chem.* **1981**, *46*, 2280.
15. Mannich, C.; Chang, F.T. *Chem. Ber.* **1933**, *66*, 418.
16. Tashmukhamedova, A. K.; Abdulaeva R. A.; Stempnevskaya, I. A.; Saifulina, N. J.; Adibekov, M. T. *Bioorgan. Khim.* **1978**, *4*, 806.
17. Grebenuyk, A. D.; Andreev, S. A.; Stempnevskaya, I. A.; Levkovich, M. G.; Tashmukhamedova, A. K. *Khim. Geterocycl. Soed.* **2000**, *12*, 1688.
18. Gorodnyuk V. P.; Grigorash, Z. Ya.; Chuprin, G. N.; Kotlyar, S. A. *Zh. Obshch. Khim.* **1998**, *68*, 1051.
19. *Organic Syntheses, Coll. Vol. 2*. Edited by Blatt, A., Ed.; New York, 1949, p 105.
20. Klyatskaya, S. V.; Tretyakov, E. V.; Vasilevsky S. F. *Russian Chem. Bulletin. Int. Ed.* **2002**, *51*, 128.