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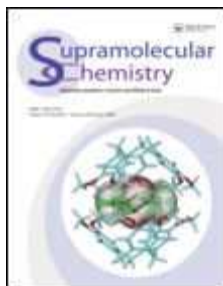
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<p>Note: The following files were submitted by the author for peer review, but cannot be converted to PDF. You must view these files (e.g. movies) online.</p> <p>scheme1.cdx scheme2.cdx scheme3.cdx</p>	



Synthesis of Chiral Phenolic 1,1'-Binaphthocrown Ethers and Some Proton-Ionisable Chromogenic Derivatives

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Abstract—Synthesis of mono- and bis(1,1'-bi-2-naphthocrown)ethers containing bis(2,6-methylene)anisyl subunit in the crown ring were developed. These chiral macrocycles are suitable precursors to introduce chromogenic function, as exemplified by two novel crowned azophenol chromoionophores. Their coloration process induced by various achiral and chiral amines was studied by UV-vis spectrophotometry.

Abbreviated title for running headlines: Binaphthocrown ethers

Keywords: BINOL, Crowned azophenols, Amine recognition, UV-vis spectroscopy

INTRODUCTION

Over the last decades 1,1'-bi-2-naphthyl derivatives have received constantly growing interest as chiral catalyst, mediators and chelators in asymmetric syntheses and chiral recognition processes [1]. BINOL (1,1'-bi-2-naphthol) has become one of the best known and utilized atropisomer possessing axial chirality due to its easy availability and versatile chemical modifications on the aromatic core and on the phenolic OH groups as well [1b,c]. The replacement of the latter with *C*, *S*, *N*- and *P* functionalities further expand the versatility of chiral ligands based on BINOL. The *O,O*-cyclized derivatives and related macrocycles also represent an important family of chiral receptors [2]. (*S,S*)-bis(1,1'-Bi-2-naphtho)-22-crown-6, reported first by Cram *et al.* in 1973 [3], was disclosed to exhibit remarkable chiral discrimination between the enantiomers of organic ammonium salts since the receptor possesses C_{2v} axis of symmetry due to the steric

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4 effect between the naphthalene rings. So far the choice of binaphthocrowns have
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6 scarcely been widened, only modifications on the crown ether ring size and some
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8 combination with calix[4]arenes were reported [4,5]. In the mean time, the number of
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10 chiral crown ethers based on natural chiral sources or constructed by introduction of
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12 asymmetric elements in the crown rings, have significantly increased [6]. However,
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14 some recent publication revealed that binaphthocrowns with auxiliary binding sites
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16 attached to the crown ether ring may have potential in various recognition processes [7-
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18 9]. Another way to modify the binding characteristics of binaphthocrowns is to insert a
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20 bis(2,6-methylene)anisyl subunit in the crown ring (**I**), which provides an easy access to
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22 proton-ionisable chromogenic chelators (type **II**) (Fig. 1). This approach has been
23
24 frequently used for the synthesis of chiral phenolic crown ethers capable of
25
26 discriminating amine enantiomers by UV-vis spectroscopy [10-12], but hitherto this
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28 attractive way of detection has been limited to one example in the binaphthocrown series
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30 ((*R,R*-and *S,S*)-**III**) for the optical recognition of chiral amines [13].
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FIGURE 1. Anisyl-appended crown ethers and proton-ionizable chromoionophores

As part of our ongoing program to synthesize chromoionophores for developing optical sensors, we have studied the optical properties of different chromophore groups (2,4-dinitrophenylazo, indophenol, etc.) introduced to various calix[4]arenes including bridged derivatives [14]. Recently, we published a facile method to prepare binaphthomonoazacrowns [15] and some novel photochromic conjugates thereof [16]. Herein, we report on the synthesis, characterization and recognition properties of novel binaphthocrown ethers **1**, **2** (Fig. 2), which can be utilized as precursors for the synthesis of chromoionophores type **II** and **III**, e.g. by dealkylation and subsequent nitration or oxidation to quinones followed by condensation with hydrazines [11,12]. In this paper,

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4 the latter route is demonstrated by the preparation of novel chromogenic azophenols (*S*)-
5 **3a** and (*S,S*)-**3b** and their optical recognition ability toward achiral and chiral amines is
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7 also presented.
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12 FIGURE 2. Mono- and bis(binaphthocrown)ether target molecules **1** and **2** and
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14 chromoionophores **3a,b** derived from them
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16 17 18 RESULTS AND DISCUSSION 19

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21 The synthesis of **1a-c** consists of three steps: first, bis(2,6-bromomethyl)anisols **4a** [17],
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23 **b,c** [18] were condensed with diethylene glycol under strongly basic conditions [19]
24
25 affording diols **5a-c**, which were then tosylated to give the cyclizing agents **6a-c**. The
26
27 ring closure reaction was carried out with (*R*) or (*S*)-BINOL promoted by K₂CO₃ in
28
29 boiling MeCN to give binaphthocrowns **1a-c** in yields of 30-70% (Scheme 1).
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34 SCHEME 1. Synthesis of binaphthomonocrowns **1a-c**. Reagents and conditions: (i)
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36 diethylene glycol, powdered NaOH, 100°C (**5a-c**), (ii) TsCl, THF, powdered KOH, 0°C,
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38 (iii) BINOL, K₂CO₃, MeCN, 80°C
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42 The synthesis of bis(binaphthocrown)ethers **2a-c** required first the protection of one OH
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44 group of BINOL, which was easily achieved by acylation with pivaloyl chloride to give
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46 monoester **7** [20]. This compound was then smoothly alkylated with **4a** and **4c** to give
47
48 **8a** and **8b**, respectively, followed by deprotection with aq. NaOH furnishing the
49
50 precursors **9a,b**. The cyclizations were then performed with tri- and tetraethylene glycol
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52 ditosylates (route A) and **2a-c** were obtained in 20-25% overall yields. Another
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54 approach, when intermediate **11a,b** were cyclized with **4a** using Cs₂CO₃ base as
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described in ref. [13] (route **B**), was also successful giving the same products in comparable yields (Scheme 2).

SCHEME 2. Synthesis of bis(binaphtho)crowns **2a-c**. Reagents and conditions: (i/1) **4a,d**, K₂CO₃, MeCN, 80°C (**8a,b**), (i/2) TsO(CH₂CH₂O)_{3,4}Ts, K₂CO₃, MeCN, 80°C (**10a,b**), (ii) aq. NaOH, EtOH, 80°C (**9a,b** **11a,b**); (iii) TsO(CH₂CH₂O)_{3,4}Ts, K₂CO₃ (**2a,b**) or Cs₂CO₃ (**2c**), MeCN, 80°C (route A); (iv) **4a**, Cs₂CO₃, MeCN, 80°C (route B)

Synthesis and Spectroscopic Characterization of Chiral Crowned Azophenols

To demonstrate a way of chromogenization of anisyl-appended crown ethers **1** and **2**, proton ionisable receptors (*S*)-**3a** and (*S,S*)-**3b** were synthesized. The former was obtained from **1b** by oxidation with ammonium cerium(IV) nitrate (CAN) to quinone **14** followed by condensation with 2,4-dinitrophenylhydrazine (2,4-DNPH). Essentially this route was used for the preparation of (*S,S*)-**3b**, but the allyl protecting group of **2c** was removed prior to oxidation affording phenol **2d**, which was then treated in the same way (Scheme 3).

SCHEME 3. Synthesis of chromogenic (*S*)-**3a** and (*S,S*)-**3b**. Reagents and conditions: (i) Pd/C, *p*-TsOH, EtOH/THF, Δ (**2d**); (ii) Ce(NH₄)₂(NO₃)₆, aq. MeCN, rt; (iii) 2,4-DNPH, EtOH/CHCl₃, H⁺, rt.

UV-vis spectroscopic investigation of (S)-15 and (S,S)-17 upon addition of amines

The visible spectrum of (*S*)-**3a** and (*S,S*)-**3b** taken in chloroform and MeCN exhibited absorption maxima around 380-390 nm, which were significantly red-shifted in both solvents (180-230 nm) upon addition of achiral 1^o-3^o amines (1000 equiv.). The

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4 coloration process is due to the amine-based deprotonation of the azophenol moiety,
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6 affording a photoinduced charge transfer (PCT) [21]. The polar aprotic acetonitrile
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8 stabilizes the ammonium-phenolate ionpair more strongly than chloroform, accordingly
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10 band shifts to the lower energy region result, but without noteworthy discrimination in
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12 respect of the order of amines. In chloroform, however, **3a** responds to 1° and 2° amines,
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14 but a tertiary amine (Bu₃N) gives no coloration. Ligand **3b** behaves similarly with
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16 remarkably reduced discrimination (Fig. 3). The selectivity of **3a** toward 1°, 2° versus 3°
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18 amines is related to H-bonding interactions between the crown ring and the protons of
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20 ammonium ion formed. At the same time, none of ligands can discriminate among
21
22 primary and secondary amines as reflected by the λ_{\max} values of the new bands centered
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24 around 570-580 nm (CHCl₃) indicating complex stabilities irrespective of the number of
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26 NH⁺ protons. Primary ammonium ions are enabled to form three-pointed H-bonds with
27
28 the oxygen atoms of 18-crown-6, therefore their complexes are more stable than those of
29
30 the secondary ammonium counterparts capable of only two-pointed H-bonding
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32 interactions [22]. Accordingly, BuNH₂ would have been expected to show larger red-
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34 shift than Bu₂NH or piperidine. We suppose, the lack of selectivity may be attributed to
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36 the less flexible conformation of the binaphthocrown ring that prevents all NH₃⁺ protons
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38 to participate in binding. Obviously, the complexation selectivity is affected by other
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40 factors, e. g. interactions (steric, CH- π , hydrophobic, etc.) between the substituents of
41
42 the amine and the ligand. Recently, a selectivity enhancement of n-octylamine vs. di-n-
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44 octylamine was reported for an azophenol-crown ether ligand linked with permethylated
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46 α -cyclodextrin [23]. The critical role of the adjacent α -CD capable of interaction with
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48 the lipophilic alkyl chain by hydrophobic forces was emphasized.
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4 The larger absorbances measured for BuNH₂, Bu₂NH and piperidine as compared to
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6 benzylamine and morpholine are in accord with the different basicities (the latter are ca.
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8 2-3 order of magnitude weaker bases). Nevertheless, the weak if any coloration with a
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10 strongly basic 3° amine (Bu₃N) underlines the role of the crown ring in the
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12 complexation-induced stabilization of the ammonium-phenolate ion pair possessing at
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14 least two NH⁺ protons.
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20 FIGURE 3.. Spectral changes of (*S*)-**3a** upon addition of 1°-3° amines. [**3a**] = 10⁻⁴ M,
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22 [amine] = 10⁻¹ M, solvent: chloroform and acetonitril
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24

25
26 FIGURE 4. Spectral changes of (*S,S*)-**3b** upon addition of 1°-3° amines. [**3b**] = 10⁻⁴ M,
27
28 [amine] = 10⁻¹ M, solvent: chloroform and acetonitril
29
30

31 Preliminary measurements on the chiral discrimination ability of (*S*)-**3a** and (*S,S*)-**3b**
32
33 were performed in chloroform and acetonitrile at 25°C with α-phenylethylamine (PEA),
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35 ephedrine and D-threo-2-amino-1-*p*-nitrophenyl-1,3-propanediol (D-bases) enantiomers
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37 (Table 1).
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40
41 TABLE 1. Absorption maxima of the coloured species of (*S*)-**3a**
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43 and (*S,S*)-**3b** with chiral amines
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47 D-bases effected very weak coloration of each ligand, while (*S,S*)-**3b** did not show
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49 enantiomeric discrimination among any guests ($\Delta\lambda_{\max} = 0$ nm). For chiral crown ether-
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51 appended azophenol-amine diastereomers, the blue-shift is indicative of the better host-
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53 guest complementarity. This prediction is consistent with the binding model, where
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55 hydrogen bonding between the phenolate oxygen of the host and an NH⁺ hydrogen of
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57 the guest stabilizes the energy of the polar ground state more than the less polar excited
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4 state, thereby leading to a blue-shift [24]. Accordingly, (*S*)-**3a** exhibits some
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6 enantioselective coloration with (*R*)-PEA vs. (*S*)-PEA in MeCN ($\Delta\lambda_{\text{max}} = 2$ nm), in turn
7
8 (+)-(*1S,2R*)-ephedrine is significantly discriminated over the (-)-(*1R,2S*)-enantiomer in
9
10 both solvent ($\Delta\lambda_{\text{max}} = 8/12$ nm). This relatively high enantioselectivity can be ascribed to
11
12 the (*1S*)-OH group of ephedrine which is supposed to be H-bonded with an oxygen atom
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14 of the ring, thereby providing an additional stability for this diastereomer complex.
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19 This preliminary results encourage us to continue our studies with other chiral amines
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21 and aminoalcohols performing the spectroscopic measurements at 0°C to achieve better
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23 enantioselections [13].
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27 28 CONCLUSIONS

29
30 A series of 1,1'-bi-2-naphthyl-appended mono- and biscrown ethers containing anisyl
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32 subunit in the crown ring have been synthesized, which are considered to be useful
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34 precursors for the development of various chiral chromogenic receptors, as
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36 demonstrated by the synthesis of ligands (*S*)-**3a** and (*S,S*)-**3b** containing 2,4-
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38 dinitrophenylazo chromophore. The optical characteristics of the two azophenol ligands
39
40 were studied by UV-vis spectroscopy, in addition the coloration process induced by
41
42 various achiral and chiral amines was also investigated. Ligand (*S*)-**3a** was found to
43
44 exhibit significant enantioselective coloration toward (+)-(*1S,2R*)-ephedrine over the (-)-
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46 (*1R,2S*)-enantiomer.
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52 53 EXPERIMENTAL

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55 Melting points are uncorrected. NMR spectra were taken in CDCl₃ at 500/125 MHz on a
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57 Bruker Avance DRX-500 spectrometer. UV-vis spectra of the chromoionophores were
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4 recorded on a HP 8452A spectrophotometer. Precoated silica gel plates (Merck 60 F₂₅₄)
5
6 were used for analytical TLC and Kieselgel 60 for column chromatography. All
7
8 chemicals were reagent grade and used without further purification. Compounds **4a-c**
9
10 [17,18], **5a-c**, **6a-c** [19], and **7** [20] were prepared as reported. Deallylation of **2c** to **2d**
11
12 was carried as described in ref. [25]. Quinones (*S*)-**14** and (*S,S*)-**15** were prepared
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14 following literature analogy [11].
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16
17

18 19 20 **General procedure for the synthesis of 1,1'-binaphthocrown ethers 1a-c and 2a-c**

21
22 The mixture of BINOL (0.57g, 2 mmol), ditosylate **6a-c** (2.2 mmol) and K₂CO₃ (1.12 g,
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24 8 mmol) in MeCN (20 ml) was vigorously stirred under reflux for 20 h. The reaction
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26 mixture was evaporated to dryness and the residue was dissolved in CHCl₃ (20 ml),
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28 washed with water and dried. The volatile was distilled off in vacuo and the residue was
29
30 purified by column chromatography on silica to give **1a-c** as white amorph solids.
31
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34
35 The same procedure was used for the alkylation of BINOL-monopivalate **7** (2 mmol)
36
37 with **4a,d** or tri- and tetraethylene glycol ditosylates (1 mmol each) in the presence of
38
39 K₂CO₃ (2 mmol) followed by basic deprotection of **8a,b** and **10a,b** thus formed,
40
41 according to ref. [20], affording bis-BINOL precursors **9a,b** and **11a,b**, respectively.
42
43 The ring closure of **9a,b** (1 mmol) with ditosylates (1.1 mmol) was carried out similarly
44
45 but 10-fold excess of K₂CO₃ was required in 48 h reaction (route **A**) affording
46
47 bis(binaphthocrowns) **2a-d** as white solids after column chromatography.
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52
53 Compound (*S*)-**1a** (79%, eluent: AcOEt), [α]_D²⁰ = - 118.0 (c 1, THF); ¹H NMR δ 7.80
54
55 (m, 4H, ArH), 7.27-7.37 (m, 6H, ArH), 7.18 (t, 2H, *J* = 8.0 Hz, ArH), 7.12 (d, 3H, *J* =
56
57 6.0 Hz, ArH), 4.54 (d, 2H, *J* = 11.0 Hz, ArCH₂O), 4.47 (d, 2H, *J* = 11.0 Hz, ArCH₂O),
58
59 3.96 (m, 2H, OCH₂), 3.83 (m, 2+3H, OCH₂, OCH₃), 3.46 (m, 2H, OCH₂), 3.39 (m, 4H,
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OCH₂), 3.27 (m, 4H, OCH₂), 3.20 (m, 2H, OCH₂); ¹³C NMR δ 158.75, 154.92, 134.21,

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4 131.95, 131.63, 129.78, 129.45, 128.02, 126.29, 125.71, 123.90, 123.82, 121.18, 117.38,
5
6 (Ar), 70.79, 70.70, 69.88, 69.43 (OCH₂), 68.80 (ArCH₂O), 63.97 (OCH₃); Anal. calcd.
7
8 for C₃₇H₃₈O₇ (594.69): C 74.73, H 6.44, found C 74.52, H 6.41%.

9
10
11 Compound (*S*)-**1b** (39%, eluent: hexane-AcOEt = 1:1), mp:112-116°C, [α]_D²⁰ = - 113.5
12 (c 1, THF); ¹H NMR δ 7.82 (m, 4H, ArH), 7.36 (d, 2H, *J* = 9.0 Hz, ArH), 7.29 (t, 2H, *J*
13 = 6.5 Hz, ArH), 7.18 (t, 2H, *J* = 7.0 Hz, ArH), 7.12 (d, 2H, *J* = 8.5 Hz, ArH), 6.88 (s,
14 2H, ArH), 4.55 (d, 2H, *J* = 11.5 Hz, ArCH₂O), 4.45 (d, 2H, *J* = 11.5 Hz, ArCH₂O), 3.97
15 (m, 2H, OCH₂), 3.84 (m, 2+3H, OCH₂, OCH₃), 3.73 (s, 3H, OCH₃), 3.47-3.37 (m, 6H,
16 OCH₂), 3.31 (m, 2H, OCH₂), 3.26 (m, 2H, OCH₂), 3.19 (m, 2H, OCH₂); ¹³C NMR δ
17 155.6, 154.9, 151.9, 134.2, 132.7, 129.7, 129.4, 128.0, 126.3, 125.7, 123.9, 121.1, 117.2,
18 116.1, (Ar), 70.8, 10.6, 69.8, 69.4, 68.6, (OCH₂), 63.8, 55.9, (OCH₃); Anal. calcd. for
19 C₃₈H₄₀O₈ (624.72): C 73.06, H 6.45, found C 72.87, H 6.51%.

20
21
22 Compound (*S*)-**1c** (34%, eluent: hexane-AcOEt = 1:1), mp 136-139°C (CH₃OH), [α]_D²⁰
23 = - 98.2 (c 1, THF); ¹H NMR δ 7.82 (d, 4H, *J* = 8.5 Hz, ArH), 7.47 (s, 2H, ArH), 7.36
24 (d, 2H, *J* = 9.0 Hz, ArH), 7.30 (t, 2H, *J* = 7.5 Hz, ArH), 7.18 (t, 2H, *J* = 8.0 Hz, ArH),
25 7.12 (d, 2H, *J* = 8.5 Hz, ArH), 4.51 (d, 2H, *J* = 11.5 Hz, ArCH₂O), 4.42 (d, 2H, *J* = 11.5
26 Hz, ArCH₂O), 3.97 (m, 2H, OCH₂), 3.83 (m, 2H, OCH₂), 3.75 (s, 3H, OCH₃), 3.45 (m,
27 2H, OCH₂), 3.38 (m, 4H, OCH₂), 3.28 (m, 4H, OCH₂), 3.17 (m, 2H, OCH₂); ¹³C NMR δ
28 157.4, 154.9, 134.3, 134.2, 133.7, 129.8, 129.5, 128.0, 126.3, 125.7, 123.9, 121.2, 117.3,
29 116.5, (Ar), 70.8, 70.7, 69.9, 69.6, 68.2, (OCH₂), 63.8 (OCH₃); Anal. calcd. for
30 C₃₇H₃₇BrO₇ (673.59): C 65.97, H 5.54, found C 66.12, H 5.62%.

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32
33 Compound (*S,S*)-**9a** (98%), [α]_D²⁰ = - 62.0 (c 1, THF); (*R,R*)-**9a** (90%), [α]_D²⁰ = + 62.3
34 (c 1, THF); ¹H NMR δ 7.94 (d, 2H, *J* = 9.0 Hz, ArH), 7.84 (m, 4H, ArH), 7.80 (d, 2H, *J*
35 = 8.0 Hz, ArH), 7.44 (d, 2H, *J* = 9.0 Hz, ArH), 7.35 (t, 2H, *J* = 7.5 Hz, ArH), 7.25 (m,
36 6H, ArH), 7.18 (d, 2H, *J* = 8.5 Hz, ArH), 7.11 (t, 2H, *J* = 8.0 Hz, ArH), 6.97 (d, 2H, *J* =
37 8.5 Hz, ArH), 6.77 (d, 2H, *J* = 8.0 Hz, ArH), 6.63 (t, 1H, *J* = 7.5 Hz, ArH), 5.05 (d, 2H,
38 *J* = 12.5 Hz, ArCH₂O), 4.99 (d, 2H, *J* = 12.5 Hz, ArCH₂O), 3.20 (s, 3H, OCH₃); ¹³C
39 NMR δ 155.56, 155.09, 151.49, 134.287, 134.04, 131.10, 130.03, 129.96, 129.30,
40 129.20, 128.34, 128.20, 127.49, 126.58, 125.25, 125.07, 124.66, 124.50, 123.41, 117.69,
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117.04, 116.12, 115.34 (Ar), 66.22 (ArCH₂O), 62.38 (OCH₃); Anal. calcd. for C₄₉H₃₆O₅ (704.81): C 83.50, H 5.15, found C 83.29, H 5.12%.

Compound (*S,S*)-**9b** (91%), [α]_D²⁰ = - 59.0 (c 1, THF); ¹H NMR δ 7.97 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.86 (d, 2H, *J* = 8.0 Hz, Ar*H*), 7.83 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.78 (d, 2H, *J* = 8.0 Hz, Ar*H*), 7.45 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.35 (t, 2H, *J* = 7.0 Hz, Ar*H*), 7.29-7.20 (m, 6H, Ar*H*), 7.16 (d, 2H, *J* = 8.5 Hz, Ar*H*), 7.1 (t, 2H, *J* = 8.5 Hz, Ar*H*), 6.98 (d, 2H, *J* = 8.5 Hz, Ar*H*), 6.31 (s, 2H, Ar*H*), 5.79 (m, 1H, =CH), 5.19 (dd, 1H, *J* = 17.5, 1.5 Hz, =CH₂), 5.14 (dd, 1H, *J* = 10.5, 1.0 Hz, =CH₂), 5.05 (d, 2H, *J* = 12.5 Hz, OCH₂Ar), 4.97 (d, 2H, *J* = 13.0 Hz, OCH₂Ar), 3.81 (dd, 1H, *J* = 13.0, 5.5 Hz, OCH₂CH), 3.67 (dd, 1H, *J* = 12.5, 5.0 Hz, OCH₂CH), 3.18 (s, 3H, OCH₃); ¹³C NMR δ 155.98, 154.93, 151.54, 147.53, 134.28, 134.02, 133.73, 131.11, 129.88, 129.26, 128.34, 128.16, 127.48, 126.64, 125.20, 125.00, 124.60, 123.41, 117.76, 117.43, 116.94, 115.76, 115.36, 113.60, (Ar), 75.64 (OCH₂), 66.16 (ArCH₂O), 55.30 (OCH₃); Anal. calcd. for C₅₂H₄₀O₆ (760.87): C 82.08, H 5.30, found C 81.55, H 5.38%.

Compound (*R,R*)-**2a** (85%, eluent: hexane-AcOEt = 6:4), [α]_D²⁰ = + 156.8 (c 1, THF); ¹H NMR δ 7.92 (m, 4H, Ar*H*), 7.85 (m, 4H, Ar*H*), 7.46 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.42 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.31 (m, 4H, Ar*H*), 7.24-7.11 (m, 8H, Ar*H*), 6.90 (d, 2H, *J* = 7.5 Hz, Ar*H*), 6.76 (t, 1H, *J* = 7.5 Hz, Ar*H*), 5.04 (d, 2H, *J* = 12.0 Hz, ArCH₂O), 4.90 (d, 2H, *J* = 12.5 Hz, ArCH₂O), 4.08 (m, 2H, OCH₂), 3.84 (m, 2H, OCH₂), 3.40 (m, 2H, OCH₂), 3.15 (m, 2H, OCH₂), 3.02 (s, 3H, OCH₃), 2.85 (d, 2H, *J* = 7.0 Hz, OCH₂), 2.77 (d, 2H, *J* = 7.0 Hz, OCH₂); ¹³C NMR δ 156.07, 154.18, 154.02, 134.25, 134.17, 130.37, 129.62, 129.50, 129.31, 129.22, 129.16, 129.08, 127.79, 126.30, 125.44, 123.86, 123.78, 123.63, 121.02, 120.29, 116.25, 115.71, (Ar), 70.21, 69.73, 68.72 (OCH₂), 66.65 (ArCH₂O), 61.92, (OCH₃); Anal. calcd. for C₅₅H₄₆O₇ (818.95): C 80.66, H 5.66, found C 80.48, H 5.60%.

Compound (*R,R*)-**2b** (35%, eluent: hexane-AcOEt = 4:6), [α]_D²⁰ = + 143.6 (c 1, THF); ¹H NMR δ 7.94 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.86 (m, 6H, Ar*H*), 7.44 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.33 (m, 6H, Ar*H*), 7.24-7.12 (m, 8H, Ar*H*), 6.99 (d, 2H, *J* = 7.5 Hz, Ar*H*), 6.81 (t, 1H, *J* = 7.5 Hz, Ar*H*), 5.07 (d, 2H, *J* = 13.0 Hz, ArCH₂O), 4.94 (d, 2H, *J* = 12.5 Hz,

ArCH₂O), 4.12 (m, 2H, OCH₂), 3.95 (m, 2H, OCH₂), 3.50 (m, 2H, OCH₂), 3.31 (m, 2H, OCH₂), 3.18 (s, 3H, OCH₃), 3.10 (m, 8H, OCH₂); ¹³C NMR δ 155.74, 154.56, 154.34, 134.43, 130.68, 129.69, 129.60, 129.49, 129.38, 129.25, 128.04, 126.57, 126.48, 125.70, 125.66, 124.25, 123.95, 123.89, 121.11, 120.58, 116.62, 115.85 (Ar), 70.66, 70.45, 69.97, 69.51 (OCH₂), 66.86 (ArCH₂O), 61.99 (OCH₃); Anal. calcd. for C₅₇H₅₀O₈ (863.00): C 79.33, H 5.84, found C 79.02, H 5.88%.

Compound (*S,S*)-**2c** (32%, eluent: hexane-AcOEt = 7:3), [α]_D²⁰ = -96.1 (c 1, THF); ¹H NMR δ 7.93 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.90 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.84 (t, 4H, *J* = 7.5 Hz, Ar*H*), 7.47 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.41 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.31 (t, 4H, *J* = 6.5 Hz, Ar*H*), 7.23-7.14 (m, 6H, Ar*H*), 7.09 (d, 2H, *J* = 8.5 Hz, Ar*H*), 6.45 (s, 2H, Ar*H*), 5.46 (m, 1H, =CH), 5.01-4.92 (m, 4+2H, OCH₂Ar, =CH₂), 4.2-4.09 (m, 2H, OCH₂CH), 4.04 (m, 2H, OCH₂), 3.81 (m, 2H, OCH₂), 3.39 (m, 2H, OCH₂), 3.21 (s, 3H, OCH₃), 3.13 (m, 2H, OCH₂), 2.88 (m, 2H, OCH₂), 2.82 (m, 2H, OCH₂); ¹³C NMR δ 155.52, 154.38, 154.01, 148.62, 134.37, 133.98, 131.77, 130.03, 129.64, 129.59, 129.54, 129.34, 128.06, 128.01, 126.62, 126.57, 125.68, 125.60, 123.97, 123.94, 120.82, 120.69, 116.63, 116.13, 115.87, 114.32, (Ar), 75.54 (OCH₂CH), 70.49, 69.86, 69.17 (OCH₂), 66.59 (ArCH₂O), 55.31 (OCH₃); Anal. calcd. for C₅₈H₅₀O₈ (875.01): C 79.61, H 5.76, found C 79.32, H 5.80%.

Compound (*S,S*)-**2d** (67%), [α]_D²⁰ = -111 (c 1, THF); ¹H NMR δ 7.97 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.92 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.86 (d, 2H, *J* = 8.0 Hz, Ar*H*), 7.84 (d, 2H, *J* = 9.5 Hz, Ar*H*), 7.47 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.43 (d, 2H, *J* = 9.0 Hz, Ar*H*), 7.32 (m, 4H, Ar*H*), 7.19 (m, 6H, Ar*H*), 7.10 (d, 2H, *J* = 8.5 Hz, Ar*H*), 6.31 (s, 2H, Ar*H*), 5.07 (q, 4H, OCH₂Ar), 4.11 (m, 2H, OCH₂), 3.89 (m, 2H, OCH₂), 3.44 (m, 2H, OCH₂), 3.20 (m, 2H, OCH₂), 3.13 (s, 3H, OCH₃), 2.80 (s, 4H, OCH₂); ¹³C NMR δ 154.10, 153.43, 152.81, 146.09, 134.13, 134.11, 129.91, 129.57, 129.47, 129.43, 128.02, 127.95, 126.56, 126.49, 125.53, 125.41, 125.08, 123.91, 123.83, 120.26, 120.09, 115.75, 114.79, 112.58, (Ar), 70.76, 70.38, 69.54, 69.45, 69.26, 68.82 (OCH₂), 68.01 (ArCH₂O), 55.25 (OCH₃); Anal. calcd. for C₅₅H₄₆O₈ (834.95): C 79.12, H 5.55, found C 78.87, 5.52%.

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Compound (*S*)-**14** (52%, eluent: hexane-AcOEt = 1:1); ^1H NMR δ 7.92 (d, 2H, $J = 9.0$ Hz, ArH), 7.84 (d, 2H, $J = 8.5$ Hz, ArH), 7.39 (d, 2H, $J = 9.0$ Hz, ArH), 7.31 (t, 2H, $J = 8.0$ Hz, ArH), 7.2 (t, 2H, $J = 8.0$ Hz, ArH), 7.15 (d, 2H, $J = 8.0$ Hz, ArH), 6.73 (s, 2H, ArH), 4.39 (d, 2H, $J = 15.5$ Hz, ArCH₂O), 4.21 (d, 2H, $J = 15.5$ Hz, ArCH₂O), 4.02 (m, 2H, ArOCH₂), 3.88 (m, 2H, ArOCH₂), 3.46 (m, 4H, OCH₂), 3.29 (m, 2H, OCH₂), 3.21 (m, 4H, OCH₂), 3.05 (m, 2H, OCH₂); ^{13}C NMR δ 188.1, 186.9, 154.8, 146.0, 134.2, 132.3, 129.8, 129.7, 128.0, 126.4, 125.8, 124.0, 121.1, 117.0, (Ar), 71.2, 71.1, 70.8, 70.3, 67.1, (OCH₂); Anal. calcd. for C₃₆H₃₄O₈ (594.65): C 72.71, H 5.76, found C 72.56, H 5.71%.

Compound (*S,S*)-**15** (94%); ^1H NMR δ 7.95 (t, 4H, $J = 10.0$ Hz, ArH), 7.86 (d, 4H, $J = 7.5$ Hz, ArH), 7.40 (dd, 4H, $J = 9.0, 3.5$ Hz, ArH), 7.33 (m, 4H, ArH), 7.21 (t, 4H, $J = 8.0$ Hz, ArH), 7.15 (d, 2H, $J = 8.5$ Hz, ArH), 7.09 (d, 2H, $J = 8.5$ Hz, ArH), 6.27 (s, 2H, ArH), 4.82 (d, 2H, $J = 16.5$ Hz, ArCH₂O), 4.66 (d, 2H, $J = 16.5$ Hz, ArCH₂O), 4.10 (m, 2H, OCH₂), 3.93 (m, 2H, OCH₂), 3.48 (m, 2H, OCH₂), 3.32 (m, 2H, OCH₂), 3.18 (s, 4H, OCH₂); ^{13}C NMR δ 186.94, 185.66, 153.92, 153.89, 153.84, 134.07, 133.94, 132.97, 131.76, 130.01, 129.81, 129.75, 129.46, 129.30, 127.92, 127.88, 126.60, 126.38, 125.52, 125.17, 124.24, 123.84, 121.86, 119.67, 117.61, 115.17 (Ar), 70.66, 70.46, 69.93, 69.17, 68.93, 68.72, 66.26 (OCH₂); Anal. calcd. for C₅₂H₄₂O₈ (818.91): C 79.20, H 5.17, found C 79.04, H 5.25%.

Synthesis of crowned azophenols (*S*)-**3a** and (*S,S*)-**3b**

Quinone (*S*)-**14** or (*S,S*)-**15** (0.2 mmol) and 2,4-DNPH (0.042 g, 0.21 mmol) were dissolved in EtOH-CHCl₃ = 1:1 mixture (5ml), one drop of 37% HCl was added and stirred overnight at ambient temperature. The solution was then diluted with CHCl₃ (10 ml), washed with dilute aq. HCl and dried. After removal of the solvent, the residue was chromatographed on silica to give **3a,b** as orange solids.

Compound (*S*)-**3a** (59%, eluent: hexane-AcOEt = 6:4); ^1H NMR δ 8.76 (d, 1H, $J = 2.0$ Hz, ArH), 8.48 (dd, 1H, $J = 9.0, 2.5$ Hz, ArH), 7.84 (m, 7H, ArH), 7.41 (d, 2H, $J = 9.0$

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4 Hz, ArH), 7.32 (t, 2H, $J = 6.5$ Hz, ArH), 7.21 (t, 2H, $J = 8.0$ Hz, ArH), 7.17 (d, 2H, $J =$
5 8.0 Hz, ArH), 4.60 (d, 2H, $J = 12.0$ Hz, ArCH₂O), 4.56 (d, 2H, $J = 11.5$ Hz, ArCH₂O),
6 4.10 (m, 2H, ArOCH₂), 4.03 (m, 2H, ArOCH₂), 3.55 (m, 4H, OCH₂), 3.44 (m, 2H,
7 OCH₂), 3.37 (m, 2H, OCH₂), 3.28 (m, 4H, OCH₂); ¹³C NMR δ 160.95, 154.71, 149.21,
8 147.19, 146.74, 146.13, 134.25, 129.77, 129.49, 128.03, 127.82, 126.43, 126.22, 125.84,
9 125.74, 123.99, 121.11, 120.32, 120.27, 116.80, (Ar), 70.40, 70.09, 70.03, 70.00, 69.86,
10 (OCH₂); Anal. calcd. for C₄₂H₃₈N₄O₁₁ (774.77): C 65.11, H 4.94, N 7.23, found C 64.89,
11 H 5.01, N 7.12%.

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21 Compound (*S,S*)-**3b** (40%, eluent: hexane-AcOEt = 7:3); ¹H NMR δ 8.77 (d, 1H, $J = 2.0$
22 Hz, ArH), 8.50 (dd, 1H, $J = 8.5, 2.0$ Hz, ArH), 7.98 (d, 2H, $J = 9.0$ Hz, ArH), 7.88 (m,
23 5H, ArH), 7.82 (d, 2H, $J = 8.0$ Hz, ArH), 7.64 (m, 2H, ArH), 7.51 (d, 2H, $J = 9.0$ Hz,
24 ArH), 7.37-7.29 (m, 6H, ArH), 7.24-7.19 (m, 4H, ArH), 7.12 (m, 4H, ArH), 5.18 (d, 2H,
25 $J = 12.5$ Hz, ArCH₂O), 5.07 (d, 2H, $J = 12.0$ Hz, ArCH₂O), 4.06 (m, 2H, OCH₂), 3.87
26 (m, 2H, OCH₂), 3.44 (m, 2H, OCH₂), 3.26 (m, 2H, OCH₂), 2.99 (q, 4H, OCH₂); ¹³C
27 NMR \square 158.44, 154.22, 153.75, 149.23, 147.19, 146.50, 146.04, 134.26, 134.22,
28 129.99, 129.79, 129.62, 128.13, 128.10, 127.73, 126.79, 126.71, 125.80, 125.64, 125.11,
29 124.85, 124.32, 124.03, 121.17, 120.58, 120.32, 119.79, 115.94, 115.50, (Ar), 70.63,
30 69.87, 69.34 (OCH₂), 68.70 (ArCH₂O); Anal. calcd. for C₆₀H₄₆N₄O₁₁ (999.03): C 72.13,
31 H 4.64, N 5.60, found C 71.97, H 4.62, N 5.50%.

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References

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53 [1] For reviews see: (a) Brunel, J. M. *Chem. Rev.* **2005**, *105*, 857. (b) Chen, Y.; Yakta,
54 S.; Yudin, A. K. *Chem. Rev.* **2003**, *103*, 3155. (c) Kočovský, P.; Viskočil, Š.; Smrčina,
55 M. *Chem Rev.* **2003**, *103*, 3213.
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4 [2] Izatt, R. M.; Zhu, C. Y.; Huszthy, P.; Bradshaw, J. S. Enantiomeric Recognition in
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60
- [2] Izatt, R. M.; Zhu, C. Y.; Huszthy, P.; Bradshaw, J. S. Enantiomeric Recognition in
Macrocycle-Primary Ammonium Cation System. In *Crown Compounds: Toward Future
Applications*; Cooper, S. R., Ed.; VCH: New York, 1992; Chapter 12.
- [3] Kyba, E. B.; Koga, K.; Sousa, L. R.; Siegel, M. G.; Cram, D. J. *J. Am. Chem. Soc.*
1973, *95*, 2692.
- [4] Kubo, Y. *Synlett* **1999**, 161.
- [5] Bitter, I.; Kőszegi, É.; Grün, A.; Bakó P.; Pál, K.; Grofcsik, A.; Kubinyi, M.; Balázs,
B.; Tóth, G. *Tetrahedron: Asymmetry* **2003**, *14*, 1025.
- [6] Zhang, X. X.; Bradshaw, J. S.; Izatt, R. M.; *Chem. Rev.* **1997**, *97*, 3313.
- [7] Tsubaki, K.; Tanaka, H.; Kinoshita, T.; Fuji, K. *Tetrahedron* **2002**, *58*, 1679.
- [8] Tsubaki, K.; Tanaka, H.; Morikawa, H.; Fuji, K. *Tetrahedron* **2003**, *59*, 3195.
- [9] Mazaleyrat, J. P.; Wright, K.; Azzini, M.-V.; Gaucher, A.; Wakselman, M.
Tetrahedron Lett. **2003**, *44*, 1741.
- [10] Naemura, K.; Tobe, Y.; Kaneda, T. *Coord. Chem. Rev.* **1996**, *148*, 199.
- [11] Hirose, K.; Ogasahara, K.; Nishioka, K.; Tobe, Y.; Naemura, K. *J. Chem. Soc.*
Perkin Trans. 2 **2000**, 1984.
- [12] Hirose, K.; Fujiwara, A.; Matsunaga, K.; Aoki, N.; Tobe, Y. *Tetrahedron:*
Asymmetry **2003**, *14*, 555.
- [13] Yamamoto, K.; Isoue, K.; Sakata, Y.; Kaneda, T. *J. Chem. Soc. Chem. Commun.*
1992, 791.
- [14] Grün, A.; Kőszegi, É.; Balázs, B.; Tóth, G.; Bitter, I. *Supramol. Chem.* **2004**, *16*, 239,
references cited therein.
- [15] Grün, A.; Kőszegi, É.; Bitter, I. *Tetrahedron* **2004**, *60*, 5041.
- [16] Kőszegi, É.; Grün, A.; Bitter, I. *Supramol. Chem.* **2006**, *18*, 66.

- 1
2
3
4 [17] Boom, M. E.; van der Lon, S.-Y.; Ben-David, Y. S.; Linda, J. W.; Milstein, D. J.
5
6 *Am. Chem. Soc.* **1998**, *120*, 6531.
7
8
9 [18] Chu, K. Y.; Griffiths, J.; Ward, D. *J. Chem. Res. Miniprint* **1981**, 3701.
10
11 [19] Sawada, M.; Okumura, Y.; Shizuma, M.; Takai, Y.; Hidaka, Y.; Yamada, H.;
12
13 Tanaka, T.; Kaneda, T.; Hirose, K.; Misumi, S.; Takahashi, S. *J. Am. Chem. Soc.* **1993**,
14
15 *115*, 7381.
16
17
18 [20] Hocke, H.; Uozumi, Y. *Tetrahedron* **2003**, *59*, 619.
19
20
21 [21] Cobben, P. L. H. M.; Egberink, R. J. M.; Bommer, J. G.; Bergveld, P.; Verboom, W.;
22
23 Reinhoudt, D. N. *J. Am. Chem. Soc.* **1992**, *114*, 10573.
24
25
26 [22] Kaneda, T. In *Crown Ethers and Analogous Compounds*; Hiraoka, M., Ed.;
27
28 Elsevier: New York, 1992, Chapter 6.
29
30 [23] Jung, J. H.; Lee, S. J.; Kim, J. S.; Lee, W. S.; Sakata, Y.; Kaneda, T. *Org. Lett.*
31
32 **2006**, *8*, 3009.
33
34
35 [24] Kaneda, T.; Hirose, K.; Misumi, S. *J. Am. Chem. Soc.* **1989**, *111*, 742.
36
37
38 [25] Boss, R.; Sheffold, R. *Angew. Chem. Int. Ed. Eng.* **1976**, 558.
39
40
41
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Caption of Figures and Schemes

FIGURE 1. Anisyl-appended crown ethers and proton-ionizable chromoionophores

FIGURE 2. Mono- and bis(binaphthocrown)ether target molecules **1** and **2** and chromoionophores **3a,b** derived from them

FIGURE 3. Spectral changes of (*S*)-**3a** upon addition of 1°-3° amines. [**3a**] = 10⁻⁴ M, [amine] = 10⁻¹ M, solvent: chloroform and acetonitril

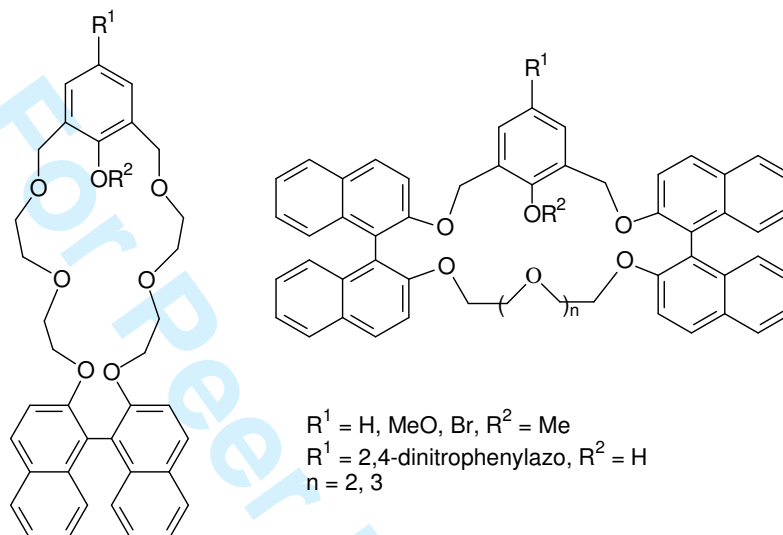
FIGURE 4. Spectral changes of (*S,S*)-**3b** upon addition of 1°-3° amines. [**3b**] = 10⁻⁴ M, [amine] = 10⁻¹ M, solvent: chloroform and acetonitril

SCHEME 1. Synthesis of binaphthomonocrowns **1a-c**. Reagents and conditions: (i) diethylene glycol, powdered NaOH, 100°C (**5a-c**), (ii) TsCl, THF, powdered KOH, 0°C, (iii) BINOL, K₂CO₃, MeCN, 80°C

SCHEME 2. Synthesis of bis(binaphtho)crowns **2a-c**. Reagents and conditions: (i/1) **4a,d**, K₂CO₃, MeCN, 80°C (**8a,b**), (i/2) TsO(CH₂CH₂O)_{3,4}Ts, K₂CO₃, MeCN, 80°C (**10a,b**), (ii) aq. NaOH, EtOH, 80°C (**9a,b** **11a,b**); (iii) TsO(CH₂CH₂O)_{3,4}Ts, K₂CO₃ (**2a,b**) or Cs₂CO₃ (**2c**), MeCN, 80°C (route **A**); (iv) **4a**, Cs₂CO₃, MeCN, 80°C (route **B**)

SCHEME 3. Synthesis of chromogenic (*S*)-**3a** and (*S,S*)-**3b**. Reagents and conditions: (i) Pd/C, *p*-TsOH, EtOH/THF, Δ (**2d**); (ii) Ce(NH₄)₂(NO₃)₆, aq. MeCN, rt; (iii) 2,4-DNPH, EtOH/CHCl₃, H⁺, rt.

Graphical abstract



Figures and Schemes

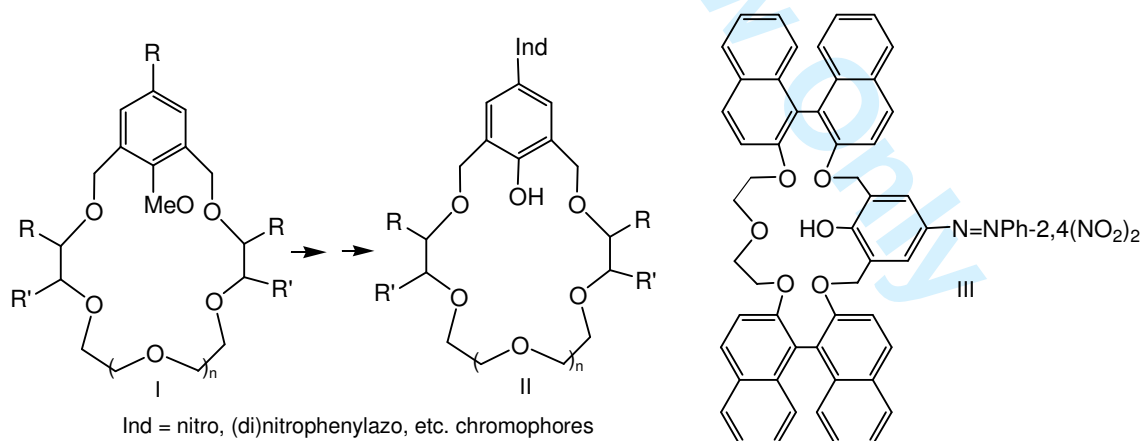


FIGURE 1. Anisyl-appended crown ethers and proton-ionizable chromoionophores.

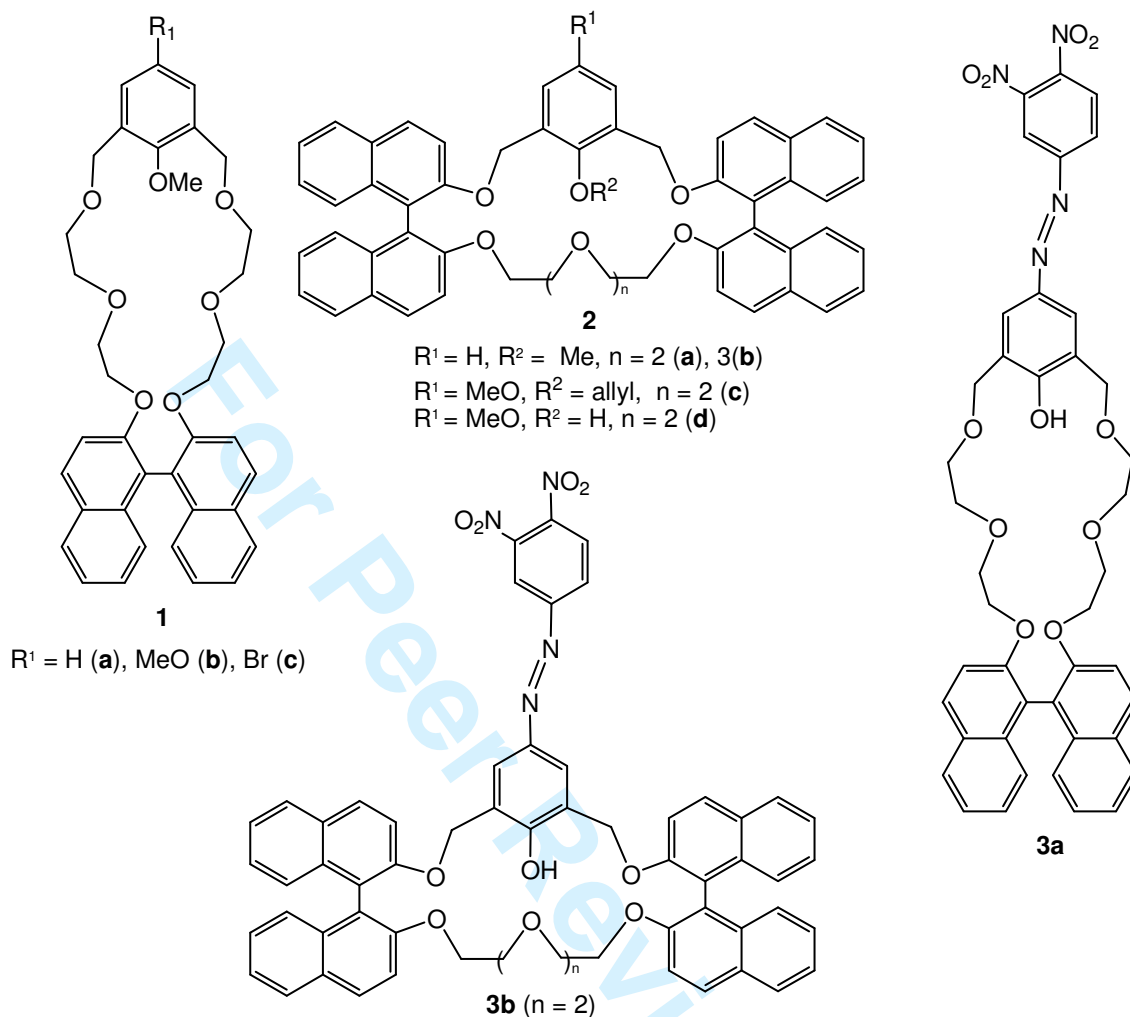


FIGURE 2. Mono- and bis(binaphthocrown)ether target molecules **1** and **2** and chromoionophores **3a,b** derived from them

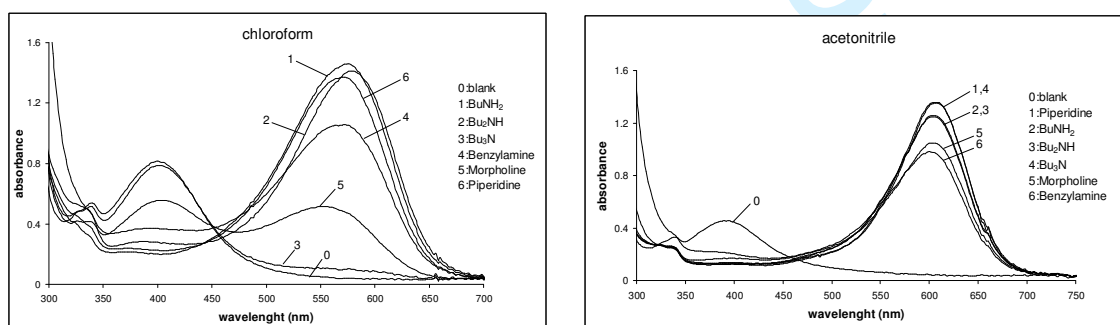


FIGURE 3. Spectral changes of (*S*)-**3a** upon addition of 1^o-3^o amines. [**3a**] = 10⁻⁴ M, [amine] = 10⁻¹ M, solvent: chloroform and acetonitril

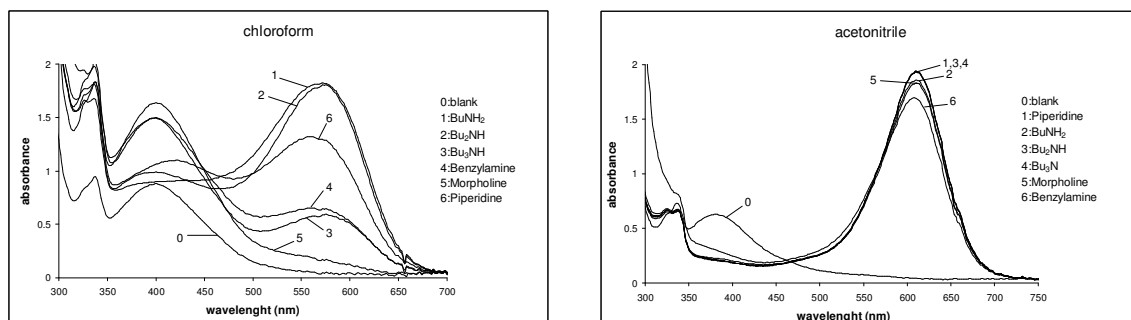
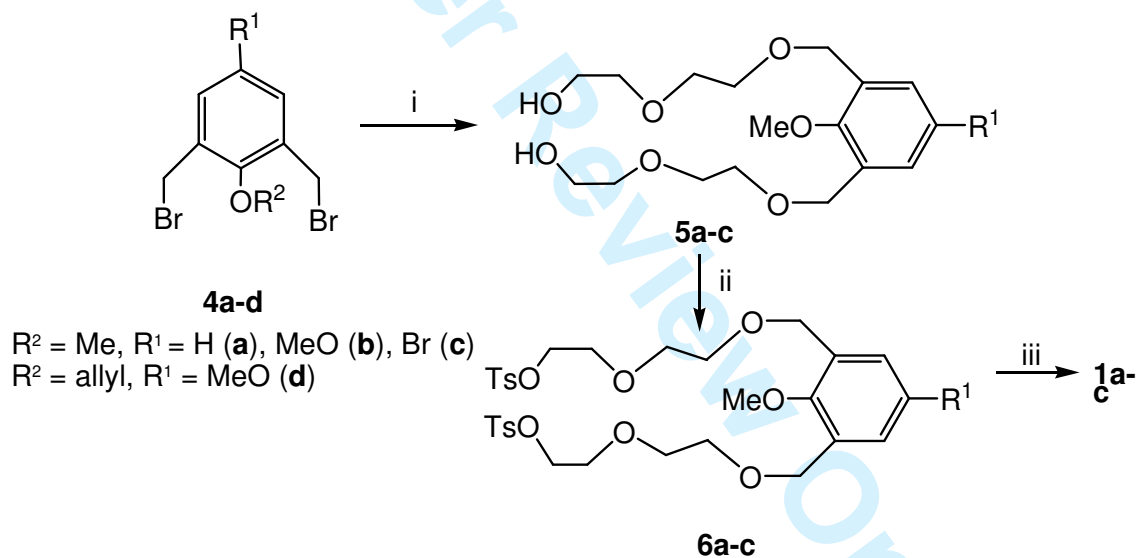
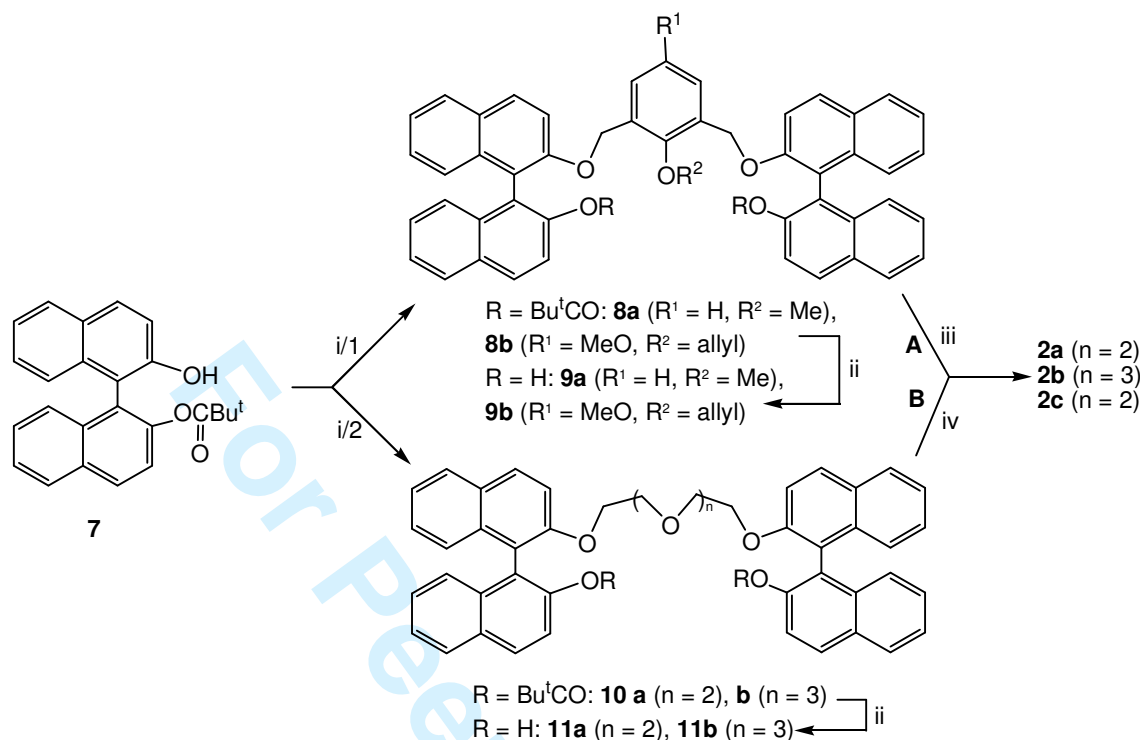


FIGURE 4. Spectral changes of (*S,S*)-**3b** upon addition 1°-3° amines. [**3b**] = 10⁻⁴ M, [amine] = 10⁻¹ M, solvent: chloroform and acetonitrile

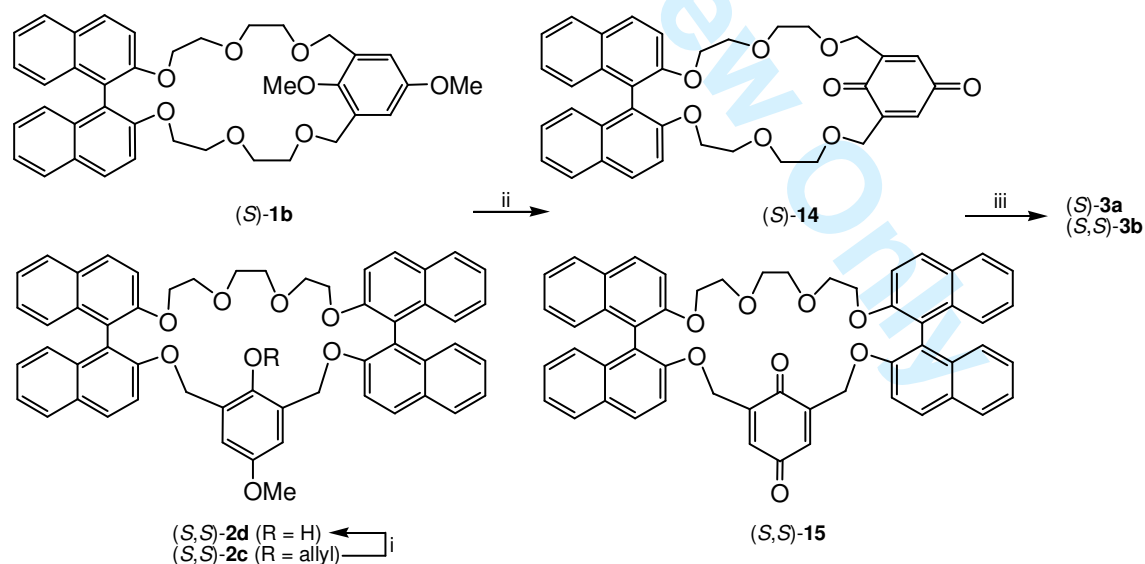


SCHEME 1. Synthesis of binaphthomonocrowns **1a-c**. Reagents and conditions: (i) diethylene glycol, powdered NaOH, 100°C (**5a-c**), (ii) TsCl, THF, powdered KOH, 0°C, (iii) BINOL, K₂CO₃, MeCN, 80°C



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SCHEME 2. Synthesis of bis(binaphtho)crowns **2a-c**. Reagents and conditions: (i/1) **4a,d**, K_2CO_3 , MeCN, 80°C (**8a,b**), (i/2) $\text{TsO}(\text{CH}_2\text{CH}_2\text{O})_{3,4}\text{Ts}$, K_2CO_3 , MeCN, 80°C (**10a,b**), (ii) aq. NaOH, EtOH, 80°C (**9a,b**, **11a,b**); (iii) $\text{TsO}(\text{CH}_2\text{CH}_2\text{O})_{3,4}\text{Ts}$, K_2CO_3 (**2a,b**) or Cs_2CO_3 (**2c**), MeCN, 80°C (route A); (iv) **4a**, Cs_2CO_3 , MeCN, 80°C (**2a**) (route B)



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SCHEME 3. Synthesis of chromogenic **(S)-3a** and **(S,S)-3b**. Reagents and conditions: (i) Pd/C, *p*-TsOH, EtOH/THF, Δ (**2d**); (ii) $\text{Ce}(\text{NH}_4)_2(\text{NO}_3)_6$, aq. MeCN, rt; (iii) 2,4-DNPH, EtOH/ CHCl_3 , H^+ , rt.

Table 1. Absorption maxima of the coloured species of (*S*)-**3a** and (*S,S*)-**3b** with chiral amines

Host	Amine	λ_{\max}/nm (ϵ)		$\Delta\lambda_{\max}$ (nm)
		CHCl ₃	MeCN	
<i>(S)</i> - 3a	(<i>R</i>)-PEA	576 (18310)	600 (24020)	0/2
	(<i>S</i>)-PEA	576 (16550)	602 (25240)	
<i>(S,S)</i> - 3b	(<i>R</i>)-PEA	576 (7740)	610 (33230)	0/0
	(<i>S</i>)-PEA	576 (9150)	610 (33340)	
<i>(S)</i> - 3a	(+)-E	548 (20750)	592 (18260)	8/12
	(-)-E	556 (18000)	604 (28200)	
<i>(S,S)</i> - 3b	(+)-E	572 (15360)	610 (36380)	0/0
	(-)-E	572 (16470)	610 (35510)	

t = 25°C, PEA: phenylethylamine, E: ephedrine, (+): 1*S*,2*R*; (-): 1*R*,2*S*

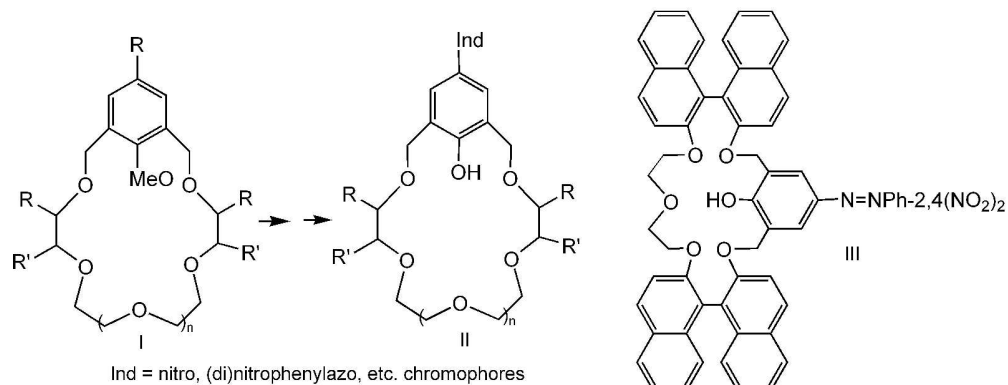


FIGURE 1. Anisyl-appended crown ethers and proton-ionizable chromoionophores
203x79mm (600 x 600 DPI)

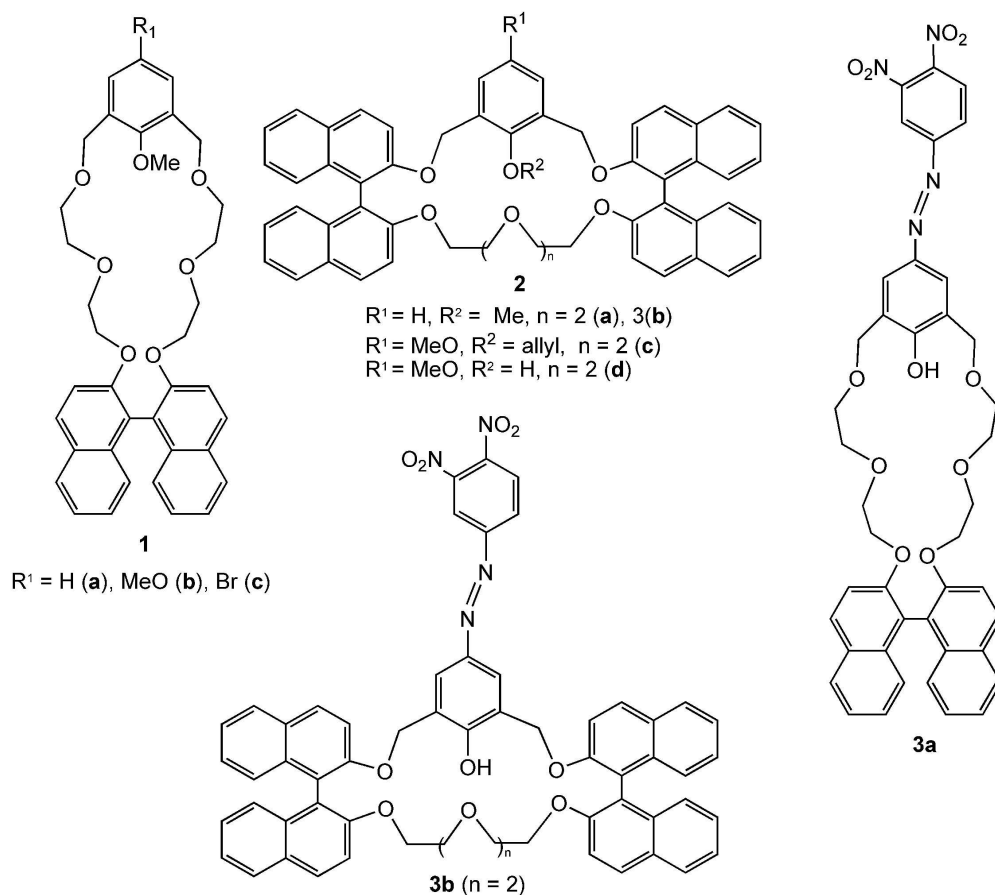
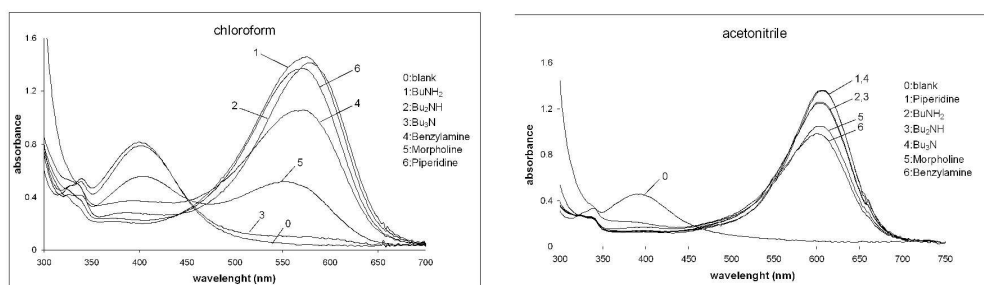
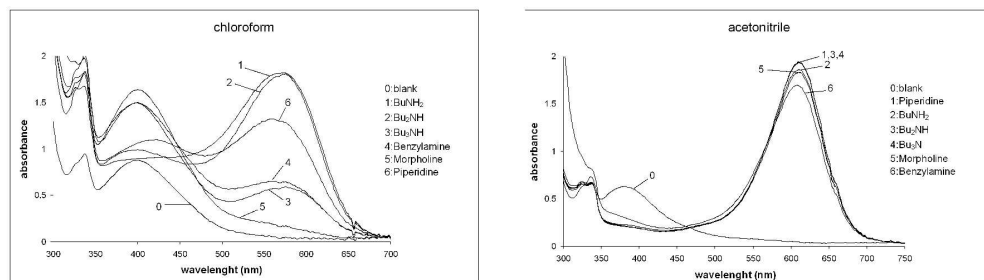


FIGURE 2. Mono- and bis(binaphthocrown) ether target molecules **1** and **2** and chromoionophores **3a, b** derived from them
190x170mm (600 x 600 DPI)



Spectral changes of (*S*)-**3a** upon addition of 1^o-3^o amines. [**3a**] = 10⁻⁴ M, [amine] = 10⁻¹ M, solvent: chloroform and acetonitril
150x44mm (600 x 600 DPI)



Spectral changes of (*S,S*)-**3b** upon addition of 1^o-3^o amines. [**3b**] = 10⁻⁴ M, [amine] = 10⁻¹ M, solvent: chloroform and acetonitril 152x44mm (600 x 600 DPI)