Ortho-Directed Lithiation of ω-Phenoxy Alcohols

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ω-Phenoxy alcohols, $PhO(CH_2)_nOH$ ($n = 2-7$), have been subjected to metalation with 2 equiv of *n*-butyllithium in tetrahydrofuran/methylcyclohexane solvent. Reaction of the resulting lithiated compounds with carbon dioxide ($n = 2-7$), benzaldehyde ($n = 2-6$), benzophenone ($n = 2$, 3), dimethylformamide ($n = 2$), ethyl formate ($n = 2$), and chlorodiphenylphosphine ($n = 3$) afforded the corresponding ortho-substituted hydroxyalkoxybenzenes in yields ranging from 45 to 83%. The synthesis is also reported of five new bis[*o*-(ω-hydroxyalkoxy)phenyl]mercury compounds ($n = 2-6$), four crystal structures of which have been determined.

Introduction

Aryllithium reagents resulting from ortho-directed metalation have found considerable synthetic application in organic and organometallic synthesis.[1] The mechanism of this important reaction has been addressed in a number of recent publications.[2] The preparation of these reagents relies on the ability of certain functional groups to facilitate deprotonation of the aromatic compound in a regiospecific manner. The number of these functional groups is considerable, and new ones are continuously being added to the list.[3,4] It has been recognized that these groups share the following two properties: first, they are capable of forming complexes with alkyllithium reagents, and second, they are devoid of electrophilic sites that could provide alternative pathways in the reaction with the alkyllithium reagent.[1b] Since alkyllithium reagents are electron deficient, they function as Lewis acids,[5] and as such they can form complexes with Lewis bases.[6] Therefore, the existence of an atom in the directed metalation group (DMG) bearing a lone pair of electrons, i.e., a heteroatom, is almost a general requirement.[1b] In addition, the ortho-directing group renders stabilization to the aryllithium product by intramolecular interactions.[1a] In certain instances, however, directed lithiation occurs via "intramolecular metalation" by an initially formed reactive side-chain metalated species.[1b,3] Still another mode of coordination between the aromatic substrate and the alkyllithium reagent leading to directed metalation is via mixed alkoxide−alkyllithium complex formation.[7] Indeed, there is ample evidence for the formation of such complexes.[8] Recently, directed lithiations have been reported from this laboratory for aromatic substrates possessing both a heteroatom and an alkoxide functionality.[4] Attempts have been made to assess the relative directing aptitude of the DMGs, and comparisons have been made by referring to the directing ability of the methoxy group.[9]

In this paper, we demonstrate the ability of the ω-lithiooxyalkoxy group to function as an ortho-directing substituent in the lithiation of aromatics. The synthetic utility of these new aryllithium reagents has been demonstated by reacting them with a series of electrophiles. In addition, we report the crystal structures of four members of a new class of organomercurials, those of bis[*o*-(ω-hydroxyalkoxy)phenyl]mercury compounds.

Results and Discussion

Lithiation of ω-Phenoxy Alcohols. Metalation of ω-phenoxy alcohols was performed using 2 equiv of *n*-butyllithium in THF/methylcyclohexane solvent. The resulting substituted phenyllithiums were derivatized by reaction with a series of ordinary electrophiles, yielding the corresponding ortho-disubstituted benzenes in yields ranging from 45 to 83%; see Scheme 1 and Table 1. The results from the derivatization of **2** ($n = 2-6$) with the three electrophiles, carbon dioxide, benzaldehyde, and

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Scheme 1

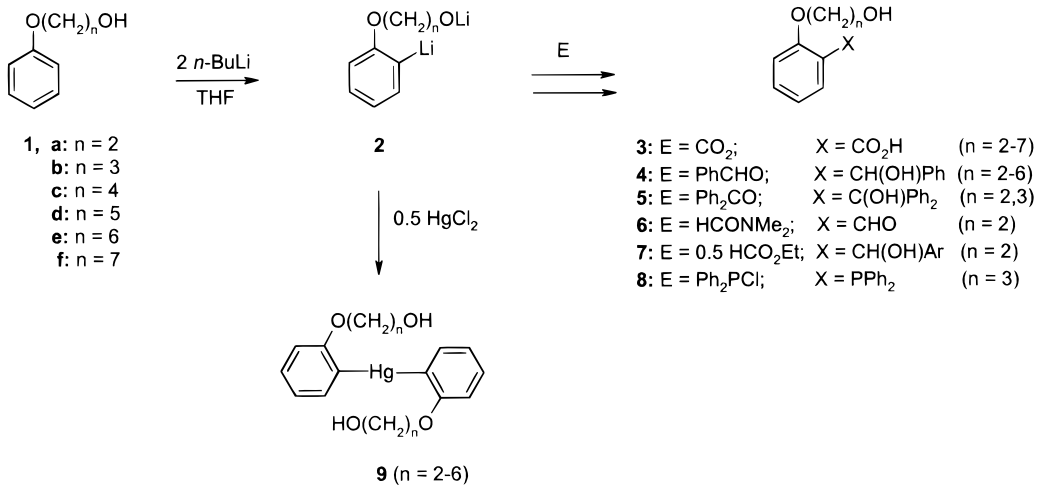

Table 1. Reactions of Organolithiums 2 with Electrophiles

organo-lithium	electro-phile	pro-duct	yield[a] (%)	mp/bp °C (solv recr/mmHg)
2a: $n = 2$	CO_2	**3a**	55	oil
2b: $n = 3$	CO_2	**3b**	63	112−114 ($PhCH_3$)[b]
2c: $n = 4$	CO_2	**3c**	57	56−58 (hexane)
2d: $n = 5$	CO_2	**3d**	79	oil
2e: $n = 6$	CO_2	**3e**	80	66−67.5 ($PhCH_3$)
2f: $n = 7$	CO_2	**3f**	83	62−63 ($PhCH_3$)
2a: $n = 2$	PhCHO	**4a**	64	70−71 ($PhCH_3$/hexane)
2b: $n = 3$	PhCHO	**4b**	75	116−118 ($PhCH_3$)
2c: $n = 4$	PhCHO	**4c**	79	92−93.5 ($PhCH_3$)
2d: $n = 5$	PhCHO	**4d**	80	101−105 ($PhCH_3$/hexane)
2e: $n = 6$	PhCHO	**4e**	83	79−81 ($PhCH_3$/hexane)
2a: $n = 2$	Ph_2CO	**5a**	59	134−136 ($PhCH_3$)
2b: $n = 3$	Ph_2CO	**5b**	83	113−114 ($PhCH_3$)
2a: $n = 2$	$HCONMe_2$	**6a**	51	132−134 °C (1)[c]
2a: $n = 2$	HCO_2Et	**7a**	59	127−128.5 (*i*-PrOH)
2b: $n = 3$	Ph_2PCl	**8b**	65	94−96 (EtOH/hexane)
2a: $n = 2$	$HgCl_2$	**9a**	45	104.5−106 (*i*-PrOH)
2b: $n = 3$	$HgCl_2$	**9b**	78	85−86.5 (EtOH)
2c: $n = 4$	$HgCl_2$	**9c**	70	80−82 (EtOH)
2d: $n = 5$	$HgCl_2$	**9d**	64	53−55 (EtOH/hexane)
2e: $n = 6$	$HgCl_2$	**9e**	72	72−74 (EtOH)

[a] Isolated yields. [b] Lit.[12] mp 107.5−109 °C. [c] Lit.[13] mp 46−46.5 °C.

mercuric chloride, allow the assessment of the reproducibility of the metalation step, provided that the reaction with all three electrophiles is quantitative. We notice, however, that the yields of a given lithio derivative, e.g., that with $n = 2$, vary considerably and that the yields with benzaldehyde are consistently higher in almost every case. Therefore, taking the metalation yield to be equivalent to the yield of the derivative with benzaldehyde, we notice a 10−15% jump in yield on going from $n = 2$ to $n = 3$ and higher and, as n in **1** increases, a tendency for the yield to level off around 80%. The consistently lower yields in the lithiation of the phenoxy alcohol with $n = 2$ implies a lower reactivity than those with $n > 2$ and that the THF cleavage reaction with BuLi becomes more competitive to the metalation reaction. The reason for the lower reactivity of 2-phenoxyethanol is not understood.[10] The reaction leading to **2** may be considered as another example of the *complex-induced proximity effect* process (CIPE).[11] Although the ω-lithioxyalkoxy group attached to benzene has two available sites for coordination with the lithiating organolithium, namely the phenoxy oxygen and the lithioxyalkyl groups, it appears to us that the lithioxyalkyl moiety is the site of attachment of the organolithium reagent, whereas the role of the phenoxy oxygen facilitates considerably the observed directed lithiation. This is born out from the reported case of directed metalation of 2-phenylethanol,[7] which, although lacking a phenoxy oxygen, undergoes ortho-metalation albeit under much more vigorous conditions, and this could be ascribed to the higher electronegativity of the $-OCH_2CH_2OLi$ group as compared to that of $-CH_2CH_2OLi$.

It is appropriate to refer to the synthetic potential of the ortho-substituted phenyllithiums reported in this work. Carboxylation and subsequent acidic hydrolysis of **2** presents simple and efficient one-pot syntheses of *o*-(ω-hydroxyalkoxy)benzoic acids **3**. Such acids are of interest as precursors to heterocyclic analogues of ortho-fused metabolites.[12] The derivatization of **2** with benzaldehyde, benzophenone, and ethyl formate yielded **4**, **5**, and **7**, respectively, which contain various types of diols and triols, primary−secondary or a primary−tertiary. These compounds could serve as starting materials for the synthesis of heterocyclic compounds. Organolithiums **2** are also useful for the introduction of the formyl group to the ortho position of the aromatic ring of the ω-phenoxy alcohols. Thus, reaction of **2a** with DMF yielded the functionalized aldehyde **6a**, potential precursor for the synthesis of "capped porphyrins", some complexes of which serve as models for the active site of the oxygen-binding haemoproteins.[13]

In addition to C−C bond formation, dilithiated species **2** were applied also to C-heteroatom bond formation. Thus, reaction of organolithium **2b** with chlorodiphenylphosphine yielded phosphine **8b**, which is of interest as a potential hemilabile P,O,O-ligand in transition-metal homogeneous catalysis.[14]

Synthesis and Crystal Structure of Bis[*o*-(ω-hydroxyalkoxy)phenyl]mercury Compounds 9. The

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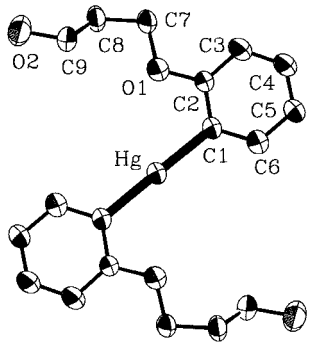

Figure 1. ORTEP drawing of **9b** at the 50% probability level. The hydrogen atoms are omitted for clarity.

synthetic value of organolithiums **2** in organometallic synthesis was demonstrated by their reaction with 0.5 equiv of mercury dichloride, yielding novel hydroxy-substituted organomercurials **9**. Suitable crystals for X-ray crystal structure determination were obtained by recrystallization of **9a** and **9b**,**c**,**e** from *i*-PrOH and EtOH, respectively. Because of the similar conformations in the crystal structures for compounds **9a**−**c**,**e**, only one ORTEP drawing, that of **9b**, is shown here (Figure 1).

In all structures, the Hg atom occupies a crystallographic center of symmetry; therefore, the two phenyl groups are coplanar, the two hydroxyalkoxy groups are trans to each other, and the C(1)−Hg−C(1) fragment is linear. In the ortho-substituted diarylmercury compounds, deviations from the coplanarity of the phenyl groups have been observed in exceptional cases, as in the structure of bis(*o*-tolyl)mercury, in which the two phenyl groups are twisted relative to one another by an angle of 58.9°, with the methyl groups on the same side of the molecule.[15] The C(1)−Hg distances in molecules **9** of about 2.06 Å are normal. The nonbonded distances between mercury and the ethereal oxygens of about 3 Å are shorter than the sum of the van der Waals radii of about 4 Å and suggest a rather weak interaction.

Conclusions

It has been demonstrated that the ω-lithioxyalkoxy group is ortho-directing in the lithiation of ω-phenoxy alcohols. The synthetic utility of these novel aryllithium compounds has been demonstrated by a number of a carbon−carbon, carbon−heteroatom, and carbon−metal bond forming reactions.

Experimental Section

General Comments. 2-Phenoxyethanol **(1a)** was commercially available. ω-Phenoxy alcohols **1b**, **1d**, and **1e** (n = 3, 5, and 6) were synthesized by the reaction of sodium phenoxide, prepared from phenol and aqueous NaOH, with the appropriate ω-halo alcohol, according to a known procedure.[16] The application of this procedure to the synthesis of 4-phenoxybutan-1-ol **(1c)**, either in water or glycol as solvent, led almost exclusively to THF as the cyclization product of 4-chlorobutan-1-ol.[17] For this reason, **1c** was synthesized by the lithium-assisted cleavage of 4-phenoxybutyl benzyl ether,[18] which in turn was prepared by the reaction of 4-phenoxybutyl bromide with sodium salt of benzyl alcohol. 7-Phenoxyheptan-1-ol **(1f)** was synthesized by the reduction of 7-phenoxyheptanoic acid,[19] which in turn was prepared from 5-phenoxypentyl bromide by malonic ester synthesis.[20] The analytical data of alcohols **1** were in accordance with those previously reported.[19,21] 4-Phenoxybutyl bromide and 5-phenoxypentyl bromide were prepared by the reaction of the corresponding α,ω-dibromoalkanes with sodium phenoxide.[20] ω-Halo alcohols were commercially available or prepared by a known procedure.[22] Lithiation reactions were performed in standard glassware with ground joints under argon. THF was distilled from $LiAlH_4$. *n*-BuLi was prepared from lithium metal and *n*-BuCl in methylcyclohexane. The organic extracts of all compounds prepared in this paper were dried over Mg_2SO_4. NMR spectra were recorded at 300 or 80 MHz (^{1}H NMR). In this paper, only selected NMR and MS data are given for the presented compounds. Melting points were not corrected. Elemental analyses were carried out at the National Hellenic Research Foundation.

Lithiation of ω-Phenoxy Alcohols 1 and Carboxylation of Lithium *ortho*-Lithioalkoxides 2. Synthesis of *o*-(ω-Hydroxyalkoxy)benzoic Acids 3. Typical Procedure. *o*-(2-Hydroxyethoxy)benzoic Acid (3a).[23] To a solution of **1a** (2.76 g, 20 mmol) in THF (15 mL) under argon was added slowly *n*-butyllithium (20.5 mL of 1.96 M solution in methylcyclohexane, 40.2 mmol) at −65 °C and stirred for 1 h. The temperature was then increased to 0 °C and maintained for 2 h, after which time the reaction mixture was stirred at room temperature overnight, yielding a white suspension. The suspension of **2a** was cooled to −65 °C and poured rapidly into a beaker containing a slurry of crushed dry ice and anhydrous diethyl ether. When the carboxylation mixture had reached room temperature, water was added and the volatile materials were removed by evaporation. The aqueous phase was washed with toluene and hexane and acidified with 20% H_2SO_4. The product was extracted with dichloromethane (5 × 50 mL) and dried. After filtration, the solvent was evaporated, yielding **3a** (2 g, 55%) as an oil**.** The NMR data were in accordance to those previously reported.[23]

***o*-(3-Hydroxypropoxy)benzoic acid (3b):**[12] ^{1}H NMR ($CDCl_3$) δ 6.10 (brs, 2H, OH and COOH), 4.35 (t, J = 5.9 Hz, 2H), 3.95 (t, J = 5.5 Hz, 2H); ^{13}C NMR ($CDCl_3$) δ 166.79, 68.37, 60.56. Anal. Calcd for $C_{10}H_{12}O_4$: C, 61.22; H, 6.16. Found: C, 61.23; H, 6.25.

***o*-(4-Hydroxybutoxy)benzoic acid (3c):** ^{1}H NMR ($CDCl_3$) δ 5.64 (brs, 2H, OH and COOH), 4.26 (t, J = 6.1 Hz, 2H), 3.73 (t, J = 5.8 Hz, 2H); ^{13}C NMR ($CDCl_3$) δ 166.91, 69.21, 61.0. Anal. Calcd for $C_{11}H_{14}O_4$: C, 62.85; H, 6.71. Found: C, 62.95; H, 6.76.

***o*-(5-Hydroxypentoxy)benzoic acid (3d):** ^{1}H NMR ($CDCl_3$) δ 5.40 (brs, 2H, OH and COOH), 4.22 (t, J = 6.2 Hz, 2H), 3.66 (t, J = 5.85 Hz, 2H); ^{13}C NMR ($CDCl_3$) δ 166.90, 69.83, 61.86. Anal. Calcd for $C_{12}H_{16}O_4$: C, 64.27; H, 7.19. Found: C, 64.48; H, 7.30.

***o*-(6-Hydroxyhexoxy)benzoic acid (3e):** ^{1}H NMR ($CDCl_3$) δ 5.63 (brs, 2H, OH and COOH), 4.25 (t, J = 6.2 Hz, 2H), 3.66 (t, J = 5.9 Hz); ^{13}C NMR ($CDCl_3$) δ 167.66, 68.37, 60.89; ESI-MS m/z (rel intesity) 261 ([M + Na]$^+$, 100). Anal. Calcd for $C_{13}H_{18}O_4$: C, 65.53; H, 7.61. Found: C, 65.33; H, 7.37.

***o*-(7-Hydroxyheptoxy)benzoic acid (3f):** ^{1}H NMR ($CDCl_3$) δ 5.89 (brs, 2H, OH and COOH), 4.20 (t, J = 6.3 Hz, 2H), 3.61

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(t, J = 6.1 Hz, 2H); ^{13}C NMR ($CDCl_3$) δ 167.46, 68.46, 61.02; ESI-MS m/z (rel intesity) 275 ([M + Na]$^+$, 100). Anal. Calcd for $C_{14}H_{20}O_4$: C, 66.65; H, 7.99. Found: C, 66.65; H, 7.89.

Reaction of 2 with Benzaldehyde or Benzophenone. Synthesis of Carbinols 4 and 5. Typical Procedure. Phenyl-[*o*-(2-hydroxyethoxy)phenyl]methanol (4a). To a suspenion of **2a** in THF (15 mL)/methylcyclohexane (23.5 mL), prepared from **1a** (2.76 g, 20 mmol) as described above, was added benzaldehyde (1.9 mL, 18.7 mmol), with ice−water bath cooling, after which time the reaction mixture was stirred at room temperature for 1 h. Water was then added, the volatile materials were removed by evaporation, the residue was extracted with dichloromethane, and the organic layer was washed with water and dried. After filtration, the solvent was evaporated, yielding 4.5 g of the crude product as a viscous oil, which was solidified and recrystallized from methylcyclohexane, yielding **4a** (3.1 g, 64%). Repeated recrystallization from toluene/hexane afforded a white solid. **4a:** mp 70−71 °C; ^{1}H NMR ($CDCl_3$) δ 6.00 (s, 1H,), 3.96 (t, J = 4.39 Hz, 2H), 3.81 (s, 1H, OH), 3.72 (m, 2H), 2.81 (s, 1H, OH); ^{13}C NMR ($CDCl_3$) δ 72.37, 69.76, 60.89; GC−MS (EI): m/z (rel intesity) 244 ($M^{\bullet+}$, 59). Anal. Calcd for $C_{15}H_{16}O_3$: C, 73.75; H, 6.60. Found: C, 73.58; H, 6.66.

Phenyl[*o*-(3-hydroxypropoxy)phenyl]methanol (4b): ^{1}H NMR ($CDCl_3$) δ 6.05 (s, 1H), 4.50 (s, 2H, 2 × OH), 3.98 (t, J = 5.9 Hz), 3.65 (t, J = 5.8 Hz, 2H); ^{13}C NMR ($CDCl_3$) δ 72.66, 65.79, 60.12; GC−MS (EI) m/z (rel intesity) 258 ($M^{\bullet+}$, 17). Anal. Calcd for $C_{16}H_{18}O_3$: C, 74.39; H, 7.02. Found: C, 74.36; H, 7.02.

Phenyl[*o*-(4-hydroxybutoxy)phenyl]methanol (4c): ^{1}H NMR ($CDCl_3$) δ 6.20 (s, 1H), 4.81 (s, 2H, 2 × OH), 4.02 (t, J = 5.7 Hz, 2H), 3.65 (t, J = 6.1 Hz, 2H); ^{13}C NMR ($CDCl_3$) δ 72.30, 67.92, 62.23; GC-MS (EI): m/z (rel intesity) 272 ($M^{+\bullet}$, 12). Anal. Calcd for $C_{17}H_{20}O_3$: C, 74.97; H, 7.40. Found: C, 74.95; H, 7.35.

Phenyl[*o*-(5-hydroxypentoxy)phenyl]methanol (4d): ^{1}H NMR ($CDCl_3$) δ 6.03 (s, 1H), 4.03 (t, J = 5.9 Hz, 2H), 3.72 (t, J = 5.8 Hz, 2H); ^{13}C NMR ($CDCl_3$) δ 72.33, 68.00, 62.55; GC−MS (EI) m/z (rel intesity) 286 ($M^{\bullet+}$, 15). Anal. Calcd for $C_{18}H_{22}O_3$: C, 75.49; H, 7.74. Found: C, 75.36; H, 7.66.

Phenyl[*o*-(6-hydroxyhexoxy)phenyl]methanol (4e): ^{1}H NMR ($CDCl_3$) δ 6.03 (s, 1H), 3.93 (m, 2H), 3.58 (t, J = 6.5 Hz, 2H), 3.35 (s, 1H, OH), 2.36 (s, 1H, OH); ^{13}C NMR ($CDCl_3$) δ 72.37, 67.79, 62.57; GC-MS (EI): m/z (rel intesity) 300 ($M^{+\bullet}$, 13). Anal. Calcd for $C_{19}H_{24}O_3$: C, 75.97; H, 8.05. Found: C, 75.71; H, 8.02.

Diphenyl[*o*-(2-hydroxyethoxy)phenyl]methanol (5a): ^{1}H NMR ($CDCl_3$) δ 5.11 (s, 1H, OH), 3.96 (t, J = 4.1 Hz, 2H), 3.55 (m, 2H), 1.19 (s, 1H, OH); ^{13}C NMR ($CDCl_3$) δ 81.60, 69.85, 60.82; GC-MS (EI): m/z (rel intesity) 320 ($M^{+\bullet}$, 5). Anal. Calcd for $C_{21}H_{20}O_3$: C, 78.73; H, 6.29. Found: C, 79.04; H, 6.39.

Diphenyl[*o*-(3-hydroxypropoxy)phenyl]methanol (5b): ^{1}H NMR ($CDCl_3$) δ 5.33 (s, 1H, OH), 3.99 (t, J = 5.9 Hz, 2H), 3.28 (t, J = 5.9 Hz, 2H), 1.45 (s, 1H, OH); ^{13}C NMR ($CDCl_3$) δ 82.03, 65.67, 59.34; GC−MS (EI) m/z (rel intesity) 334 ($M^{\bullet+}$, 2). Anal. Calcd for $C_{22}H_{22}O_3$: C, 79.02; H, 6.63. Found: C, 79.18; H, 6.73.

Reaction of 2a with DMF. Synthesis of *o*-(2-Hydroxyethoxy)benzaldehyde (6a).[13] To a suspension of **2a** in THF (55 mL)/methylcyclohexane (55 mL), prepared from **1a** (6.9 g, 50 mmol), was added a solution of DMF (3.6 g, 50 mmol) in THF (15 mL), with ice−water bath cooling, and then stirred at room temperature for 2 h. The workup procedure was as described for **4a**, yielding the crude product. Purification was carried out by distillation, yielding **6a** (4.2 g, 51%). **6a**: bp 132−134 °C (1 mmHg) (lit.[13] mp 46−46.5 °C); the ^{1}H NMR ($CDCl_3$) spectrum was in accordance with that previously reported;[13] ^{13}C NMR ($CDCl_3$) δ 190.43, 70.22, 60.72.

Reaction of 2a with Ethyl Formate. Synthesis of Bis-[*o*-(2-hydroxyethoxy)phenyl]methanol (7a). To a suspension of **2a** in THF (15 mL)/methylcyclohexane (23 mL), prepared from **1a** (2.76 g, 20 mmol), was added dropwise a solution of ethyl formate (0.74 g, 10 mmol) in THF (10 mL), with ice−water bath cooling, and then stirred at room temperature for 1 h. The workup procedure was as described for **4a**, yielding the crude product, which was recrystallized from hexane, yielding **7a** (1.8 g, 59%). Repeated recrystallization from *i*-PrOH afforded a solid. **7a**: mp 127−128.5 °C; ^{1}H NMR ($CDCl_3$) δ 6.42 (s, 1H), 2.20 (brs, 3H, OH); ^{13}C NMR (CD_3OD) δ 69.23, 64.54, 59.75. Anal. Calcd for $C_{17}H_{20}O_5$: C, 67.09; H, 6.62. Found: C, 67.35; H, 6.78.

Reaction of 2b with Chlorodiphenylphosphine. Synthesis of [*o*-(3-Hydroxypropoxy)phenyl]diphenylphosphine (8b). To a suspension of **2b** in THF (15 mL)/methylcyclohexane (23 mL), prepared from **1b** (3.05 g, 20 mmol), was added dropwise a solution of chlorodiphenylphosphine (4.2 g, 19 mmol) in THF (15 mL), with dry ice−acetone bath cooling, and then stirred at room temperature overnight. The workup procedure was as described for **4a**, yielding the crude product. Purification was carried out by recrystallization from EtOH/hexane, yielding **8b** (4.4 g, 65%) as a white solid. **8b**: mp 94−96 °C; ^{1}H NMR ($CDCl_3$) δ 7.34−6.66 (m, 14H), 4.06 (t, J = 5.7 Hz, 2H), 3.49 (t, J = 5.7 Hz, 2H), 1.94 (s, 1H, OH), 1.80 (m, 2H); ^{13}C NMR ($CDCl_3$) δ 160.16−111.07, 66.00, 59.89, 31.51; ^{31}P NMR ($CDCl_3$) δ −16.62 (ref to external H_3PO_4 85% in D_2O); GC−MS (EI) m/z (rel intesity) 336 ($M^{\bullet+}$, 24), 278 (100). Anal. Calcd for $C_{21}H_{21}O_2P$: C, 74.99; H, 6.29. Found: C, 75.19; H, 6.37.

Reaction of 2 with Mercury Chloride. Synthesis of Bis[*o*-(ω-hydroxyalkoxy)phenyl]mercury Compounds 9. Typical Procedure. Bis[*o*-(2-hydroxyethoxy)phenyl]-mercury (9a). To a suspension of **2a** in THF (50 mL)/methylcyclohexane (75 mL), prepared from **1a** (8.3 g, 60.1 mmol), was added dropwise a solution of mercury chloride (6.8 g, 25 mmol) in THF (20 mL), with ice−water bath cooling, and then stirred at room temperature overnight. The workup procedure was as described for **4a** except that the solvent used for extraction of the product being toluene. Purification of the crude was carried out by recrystallization fom *i*-PrOH, yielding **9a** (5.3 g, 45%) as a white solid. **9a**: mp 104.5−106 °C; ^{1}H NMR ($CDCl_3$) δ 4.09 (m, 4H), 3.90 (m, 4H), 3.21 (m, 2H, 2 × OH); ^{13}C NMR ($CDCl_3$) δ 70.37, 61.38; ESI-MS m/z (rel intesity) 499 ([M + Na]$^+$, 100). Anal. Calcd for $C_{16}H_{18}HgO_4$: C, 40.47; H, 3.82. Found: C, 40.32; H, 3.89.

Bis[*o*-(3-hydroxypropoxy)phenyl]mercury (9b): ^{1}H NMR ($CDCl_3$) δ 4.12 (t, J = 5.9 Hz, 4H), 3.83 (m, 4H), 2.53 (s, 2H, 2 × OH); ^{13}C NMR ($CDCl_3$) δ 65.15, 59.88; ESI-MS m/z (rel intesity) 527 ([M + Na]$^+$, 100). Anal. Calcd for $C_{18}H_{22}HgO_4$: C, 42.99; H, 4.41. Found: C, 42.97; H, 4.51.

Bis[*o*-(4-hydroxybutoxy)phenyl]mercury (9c): ^{1}H NMR ($CDCl_3$) δ 4.03 (t, J = 5.7 Hz, 4H), 3.67 (t, J = 5.7 Hz, 4H), 2.66 (brs, 2H, 2 × OH); ^{13}C NMR ($CDCl_3$) δ 68.07, 62.59; ESI-MS m/z (rel intesity) 555 ([M + Na]$^+$, 100). Anal. Calcd for $C_{20}H_{26}HgO_4$: C, 45.24; H, 4.93. Found: C, 45.27; H, 5.03.

Bis[*o*-(5-hydroxypentoxy)phenyl]mercury (9d): ^{1}H NMR ($CDCl_3$) δ 3.99 (t, J = 5.9 Hz, 4H), 3.62 (t, J = 5.8 Hz, 4H), 2.15−1.62 (m, 14H, including 2 × OH); ^{13}C NMR ($CDCl_3$) δ 68.17, 62.65. Anal. Calcd for $C_{22}H_{30}HgO_4$: C, 47.26; H, 5.41. Found: C, 47.43; H, 5.50.

Bis[*o*-(6-hydroxyhexoxy)phenyl]mercury (9e): ^{1}H NMR ($CDCl_3$) δ 3.98 (t, J = 6.3 Hz, 4H), 3.55 (m, 4H), 1.28 (s, 2H, 2 × OH); ^{13}C NMR ($CDCl_3$) δ 67.87, 62.74; ESI-MS m/z (rel intesity) 611 ([M + Na]$^+$, 100). Anal. Calcd for $C_{24}H_{34}HgO_4$: C, 49.10; H, 5.84. Found: C, 48.92; H, 5.91.

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Supporting Information Available: Full details of spectral data for compounds **3**−**9**, experimental section for the X-ray structure determinations, X-ray tables for compounds **9a**−**c**,**e**, and ORTEP drawings of **9a**,**c**,**e**. This material is available free of charge via the Internet at http://pubs.acs.org.

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