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Synthesis of periphery-functionalized dendritic polyethers

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Abstract—New dendritic polyethers with bromo-, hydroxy- and vinyl-end groups have been synthesized by a convergent strategy. Planar, 1,3,5-trischlorocarbonylbenzene and 1,3,5-trihydroxybenzene, and tetrahedral, tetrakis(*p*-hydroxyphenyl)methane, cores have been used.

1. Introduction

The synthesis and applications of new dendrimeric structures have been the focus of several research teams. Synthetic methodologies, involving convergent[1] and divergent[2] routes have been reviewed.[3] Other strategies involving 'hypermonomers',[4] exponential[5] and orthogonal[6] growth, and 'activated' monomers[7] have also been reported.

Polyether backbones have been widely used for preparing dendritic architectures by Fréchet's convergent strategies.[8] 3,5-Dihydroxybenzyl alcohol has been used as keystone for preparing a large number of dendrons and dendrimers via the iterative use of the Williamson reaction.

Modification of functional groups on the periphery of a dendritic structure offers a convenient route to new dendrimers with a structure of the external generation different from that of the first generations. This approach has been mainly used for preparing dendrimers with catalytically active centers on the periphery.[9]

This work aims at the synthesis of new periphery-functionalized dendritic polyethers having planar and tetrahedral cores.

The versatile hydroxy-, bromo- and vinyl groups have been chosen as peripheral groups and 1,3,5-trischlorocarbonyl benzene, **1**, 1,3,5-trihydroxybenzene, **2**, and tetrakis-(*p*-hydroxyphenyl) methane, **3** have been selected as cores. Core **1** has been widely used in dendrimer synthesis. Core **2** has been used only in few occasions. Chow[10] reported in 1996 the reaction of **2** with 1,3-dibromopropane to prepare polyether dendrons with a hydroxy group as focal point. In 1997, he also reported the use of 5-benzyloxy-resorcinol to built dendrimers derived from core **2**.[11] In 2002, the transformation of **2** in a extended core by reaction with 1,5-dibromopentane was described.[12] In all these papers, the dendritic growth was effected by a Williamson reaction. Also in 1996 was reported the use of **2** as core and a focal-pointed carboxyl dendron.[13] In 2002, dendrons having chlorocarbonyl as focal point have been connected to **2**.[14] The tetrahedral core **3** was used for the first time in this work.

2. Results

Figure 1 shows the hydroxy-(**A**) and bromo-(**B**) dendrons used in this work. **A**-type dendrons were prepared by reacting the appropriate benzyl halides with 3,5-dihydroxybenzyl alcohol. **B**-type dendrons were prepared by reacting **A**-type dendrons with Br_4C/Ph_3P. In the case of **7B**, these reaction conditions provoked the deprotection of phenolic hydroxy groups. Dendron **7B** was conveniently prepared by mesylation of **7A** followed by reaction with sodium bromide.

Benzyl halides were reacted with 3,5-dihydroxybenzyl alcohol in acetone/K_2CO_3 to give the corresponding **A**-dendrons. Commercial benzyl bromide, *p*-bromobenzyl bromide and *p*-vinylbenzyl chloride were used without further purification. Although the synthesis of **7A** by reduction of methyl 3,5-bis(*tert*-butyldimethylsilyloxy)-benzoate with HLA had been reported,[15] we prepared **7A** by a two-step sequence involving the protection of the three hydroxy groups of 3,5-dihydroxybenzyl alcohol with *tert*-butyldimethylsilyl chloride followed by selective deprotection of the benzylic hydroxy group with Oxone®. This procedure followed a recent communication[16] describing a similar cleavage on less functionalized *tert*-butyldimethylsilyl ethers. Dendron **8A** was prepared as described in Scheme 1. Hydroquinone was sequentially

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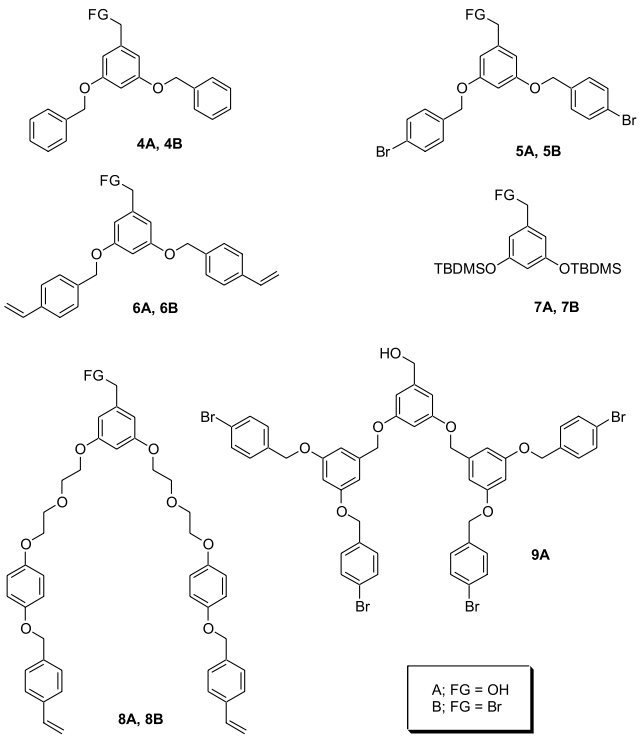
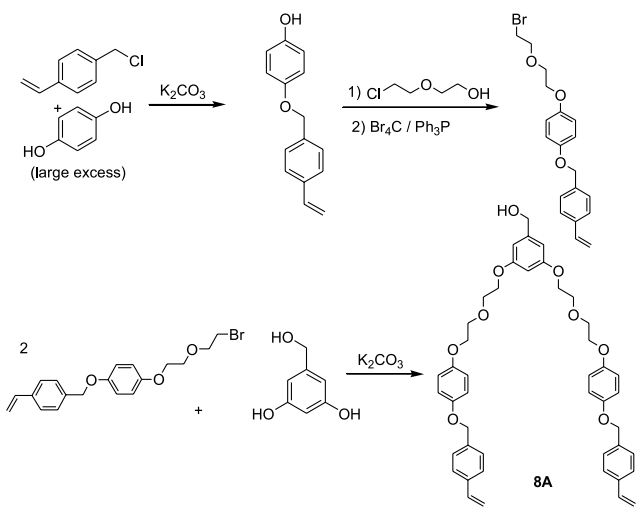


Figure 1. Hydroxy-(**A**) and bromo-(**B**) dendrons used in this work.

O,*O*-disubstituted by reactions with *p*-vinylbenzyl chloride and 2-chloroethyloxyethanol. Reaction with Br_4C/Ph_3P yielded the corresponding bromide, which was reacted with 3,5-dihydroxybenzyl alcohol giving **8A**.

Reactions of type-**A** dendrons with core **1** yielded dendrimers with ester connectivity. Esterification was performed in the presence of 4-dimethylaminopyridine following a standard procedure.[17] Dendrimer **10** was deprotected by hydrogenation yielding a new hypercore bearing six hydroxy groups **11**. Dendrimer **12** having peripheral *p*-bromophenyl groups could be useful to prepare differently substituted dendrimers.[18] Dendrimers **13** and **14** having peripheral vinyl groups are useful cross-linker in polymerization.[19] Attempts to deprotect dendrimer **15** failed probably as a result of competitive oxidation processes.



Scheme 1. Preparation of dendron **8A**.

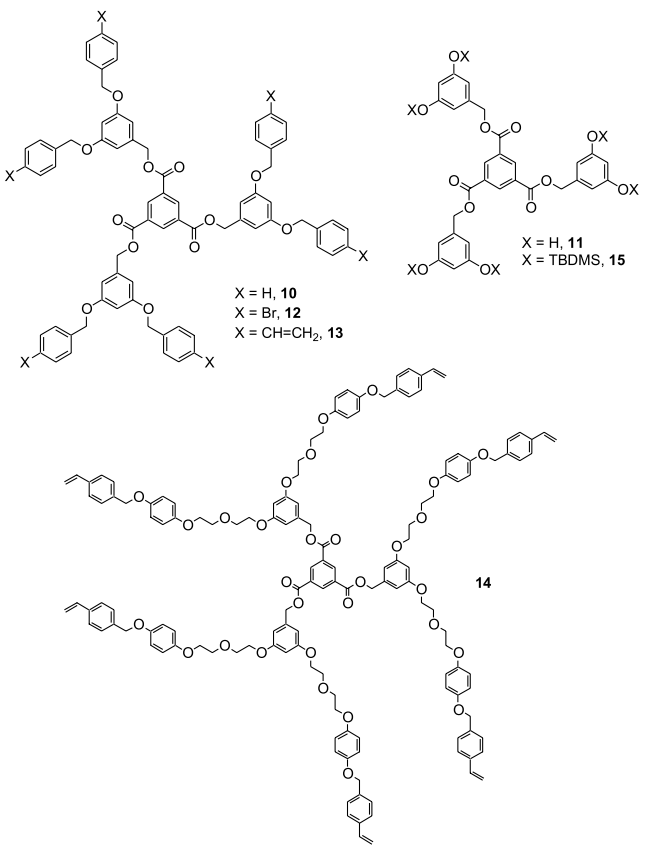


Chart 1. Periphery-functionalized dendrimers with 1,3,5-tris(oxycarbonyl) benzene **1** as core.

However, this dendrimer could be considered as a latent form of the hydroxylic hypercore **11**. Deprotection with KF followed by reaction with benzyl bromides in a one-pot procedures has been reported for related compounds.[20]

Connections to core **2** have been usually achieved by Williamson's reactions. We have also tested the Mitsunobu reaction. Results were satisfactory for small dendrons (**5A** and **7A**) but the reaction failed with a larger dendron **8A** or a second generation dendron **9A**. Dendrimers **16** and **17** were also prepared by Mitsunobu reactions (Chart 1).

It is known that peripheral *p*-bromo substituted dendrimers can be used for preparing new dendrimers.[18] Thus, dendrimer **16** was reacted with *n*-butyllithium to give the

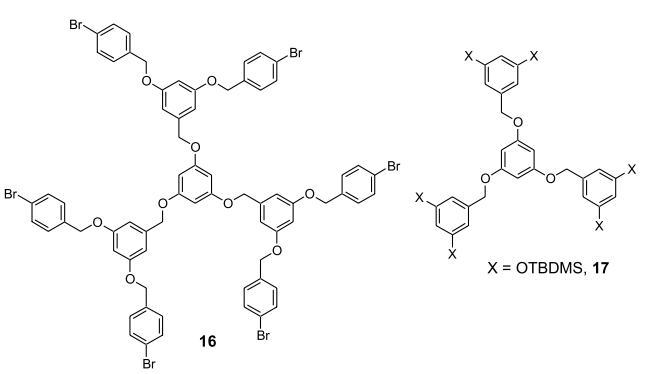


Chart 2. Pheriphery-functionalized dendrimers with phoroglucinol (1,3,5-trihydroxybenzene) **2** as core.

Table 1. Chemical shifts (δ, ppm) for benzylic methylenes

Compound	**6A**	**7A**	**8A**	**9A**	**6B**	**8B**
GF-CH_2[a]	4.62	4.56	4.60	4.61	4.41	4.38
End-CH_2[b]	5.02	–	4.99	4.96	5.02	4.99
Compound	**10**	**11**	**12**	**13**	**14**	**15**
GF-CH_2[a]	5.34	5.30	5.35	5.33	5.28	5.28
End-CH_2[b]	5.01	–	4.97	5.00	4.97	–
Compound	**16**	**17**	**18**	**19**		
GF-CH_2[a]	4.93	4.88	4.95	4.91		
End-CH_2[b]	4.97	—	5.02	4.96		

[a] Methylene close to the focal point or the core.
[b] Methylene close to the periphery.

dendritic hexa-anion as shown by a reaction with chlorotrimethylsilane. ^{1}H NMR spectra showed the complete substitution on the peripheral six phenyl rings. Dendrimer **17** can be considered as a latent hydroxylic core (Chart 2).

Core **3** was prepared from the corresponding tetraamino derivative[21] by reaction with $NaNO_2/H_2SO_4$ followed by hydrolysis of the tetradiazonium salt. Attempts to apply the Mitsunobu conditions to dendron **6A** failed. Dendrons **6B** and **8B** were reacted with core **3** following the standard procedure (K_2CO_3/acetone). Dendrimers **18** and **19** are also useful molecules for preparing polymeric support.

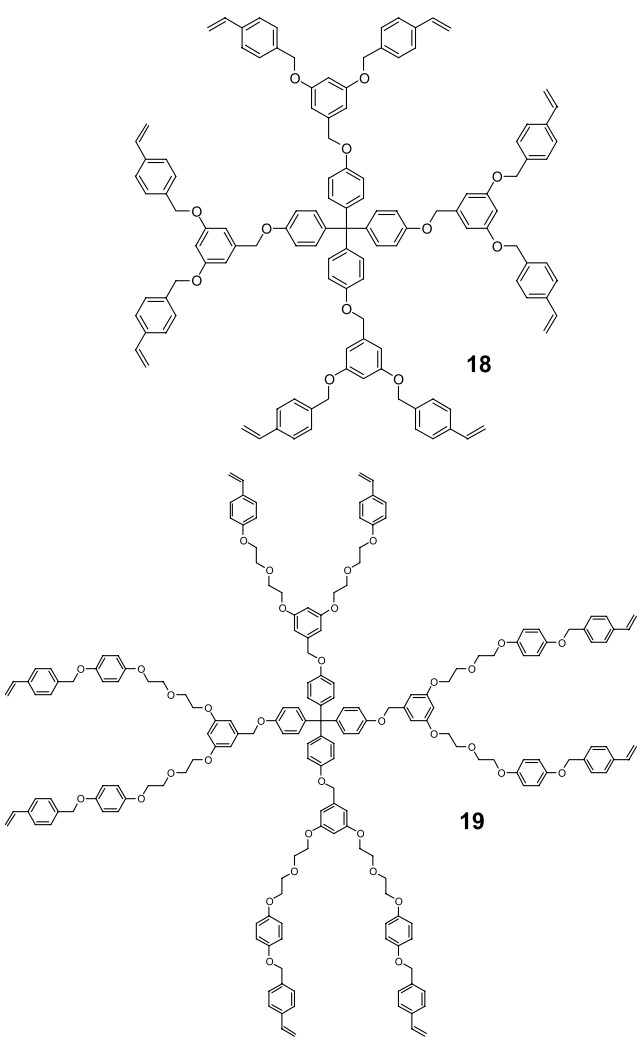


Chart 3. Peryphery-functionalized dendrimers with tetrakis(*p*-hydroxyphenyl)methane **3** as core.

The characterization of all new compounds have been performed by HRMS (except dendrimers) and ^{1}H and ^{13}C NMR and their chemical shifts are indicated in Section 3. The signals of the different benzylic methylene groups (Table 1) are significant and have been used for verify both the completion of the reactions and, the purity (>95%) of the dendrimers (Chart 3).

In conclusion, new hydroxy-, bromo- and vinyl end-capped dendritic polyethers have been prepared. Both ester and ether connectivities have been employed. Ether connectivity of small dendrons has been successfully performed under Mitsunobu reaction conditions. The tetrahedral core tetrakis(*p*-hydroxyphenyl) methane have been used for the first time.

3. Experimental

3.1. General considerations

All starting materials were purchased from Aldrich chemical Co. and Acros and were used without further purification. The following chemicals were prepared according to literature procedures: 3,5-bis(benzyloxy)-benzyl alcohol (**4A**),[1] 3,5-bis(benzyloxy)benzyl bromide (**4B**),[1] 3,5-bis(*p*-bromophenylmethyloxy)benzyl alcohol (**5A**),[22] 3,5-bis(*p*-bromophenylmethyloxy)benzyl bromide (**5B**)[22] and 3,5-bis[3,5-bis(*p*-bromophenylmethyloxy)phenyl-methyloxy] benzyl alcohol (**9A**).[22] All solvents used for extractions or reactions were dried according to standard procedures and kept over molecular sieves. Flash chromatography was run on 230–400 mesh silica-gel (Merck). NMR spectra were recorded in $CDCl_3$ using a VARIAN UNITY 300 spectrometer operating at 299.980 MHz for proton and 75.423 MHz for carbon-13 at a temperature of 293 K. Mass spectrometry was performed at the SIDI (Universidad Autónoma of Madrid).

3.1.1. Tetrakis(*p*-hydroxyphenyl)methane (3). Tetrakis-(*p*-aminophenyl)methane[21] (760 mg, 2 mmol) was placed in 20 mL of water and sulfuric acid (98%) was added dropwise until complete dissolution of the reactive. The reaction was then cooled to 0 °C and a solution of sodium nitrite (610 mg, 8.8 mmol) in 10 mL of water was added dropwise. The reaction mixture was stirred for 15 min. A solution of concentrated sulfuric acid (0.5 mL) in water (10 mL) was added and the reaction heated at 50 °C for 2 h. The solution was extracted with ethyl acetate (20 mL×3) and the combined organic layers were dried over $MgSO_4$. The crude product was purified by column chromatography (ethyl acetate). The desired compound was obtained as a brown solid after crystallization from methanol/chloroform. Mp: >270 °C. Yield 32%. ^{1}H NMR, δ (d_6-DMSO): 9.26 (s, 4H); 6.84 and 6.80 (d, 8H, A_2 of A_2B_2 system, J=8 Hz); 6.60 and 6.40 (d, 8H, B_2 of A_2B_2 system, J=8 Hz). ^{13}C NMR, δ (d_6-DMSO): 154.6, 137.8, 131.2, 114.0 and 61.4. MS (EI), *m*/*z*: 384 (M^+). HRMS, calcd for $C_{25}H_{20}O_4$ 384.1362, found 384.1382.

3.2. Preparation of dendrons

3.2.1. 3,5-Bis(*p*-vinylphenylmethyloxy)benzyl alcohol (6A). A mixture of 3,5-dihydroxybenzyl alcohol (1.4 g, 10 mmol), 4-vinylbenzyl chloride (3.2 g, 21 mmol), potassium carbonate (3.0 g, 22 mmol) and Aliquat 336 (5 mol%) in 35 mL of acetone was placed in a 100 mL round-bottom flask fitted with a condenser reflux. The reaction was heated for 12 h at 80 °C. Inorganic salts and Aliquat 336 were carried out by filtration over Florisil®, the solvent was evaporated and the crude product was crystallized in ethyl acetate/hexane as a white solid. Mp: 63–5 °C. Yield 90%. ^{1}H NMR, δ: 7.44 and 7.40 (d, 4H, A_2 of A_2B_2 system, J=8 Hz); 7.38 and 7.34 (d, 4H, B_2 of A_2B_2 system, J=8 Hz); 6.72 (dd, 2H, J_{trans}=18 Hz, J_{cis}=11 Hz); 6.61 (d, 2H, J=2 Hz); 6.53 (t, 1H, J=2 Hz); 5.76 (dd, 2H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.26 (dd, 2H, J_{gem}=1 Hz, J_{cis}=11 Hz); 5.02 (s, 4H); 4.62 (s, 2H). ^{13}C NMR, δ: 160.6, 143.9, 137.9, 136.9, 128.2, 126.9, 114.6, 112.8, 106.3, 101.9, 70.4 and 65.8. MS (EI), *m*/*z*: 372 $(M)^+$HRMS, calcd for $C_{25}H_{24}O_3$ 372.1725, found 372.1712.

3.2.2. 3,5-Bis(*tert*-butyldimethylsilyloxy)benzyl alcohol (7A).[15] In a 250 mL round-bottomed flask, *O,O,O*-tris-(*tert*-butyldimethylsilyloxy)benzyl alcohol (490 mg, 1 mmol) was dissolved in ethanol (80 mL) and a solution of Oxone® (614 mg, 1 mmol) in the minimum amount of water was added dropwise. The reaction was stirred at room temperature. The reaction was monitored by GC to fix the reaction time (4 h) avoiding higher level of deprotection. Inorganic salts were filtered off and the ethanol was evaporated. Water (25 mL) was added and the reaction was extracted with ethyl acetate (25 mL×3). The organic layer was dried over $MgSO_4$, and the solvent was evaporated after filtration. The crude product was purified by column chromatography (hexane/ethyl acetate 5:1). Mp: 45–6 °C. Yield 52%. ^{1}H NMR, δ: 6.46 (d, 2H, J=2 Hz); 6.26 (t, 1H, J=2 Hz); 4.56 (s, 2H); 0.97 (s, 9H); 0.19 (s, 6H). ^{13}C NMR, δ: 156.5, 111.7, 111.1, 94.4, 65.2, 25.8, 18.3 and −4.2. MS (EI), *m*/*z*: 368 (M^+).

3.2.3. 3,5-Bis(*p*-vinylphenylmethyloxy-*p*-phenyloxyethyleneoxyethylenoxy)benzyl alcohol (8A). A mixture of 1,4-(bromoethyleneoxyethyleneoxy), (*p*-vinylphenyloxymethyloxy)benzene (1.0 g, 2.65 mmol), KOH (154 mg, 2.70 mmol), 3,5-dihydroxybenzyl alcohol (180 mg, 1.07 mmol) and tetrabutyl ammonium bromide (TBAB) (9 mol%) was heated without solvent for 24 h at 80 °C. Ethyl acetate (20 mL) was added, the inorganic salts were filtered off and the solvent was evaporated. The crude product was purified by column chromatography (hexane/ethyl acetate 1:1). The desired compound was obtained as a white solid after crystallization from ethanol. Mp: 105–7 °C. Yield 68%. ^{1}H NMR, δ: 7.44 and 7.40 (d, 4H, A_2 of A_2B_2 system, J=8 Hz); 7.39 and 7.35 (d, 4H, B_2 of A_2B_2 system, J=8 Hz); 6.91–6.81 (m, 8H); 6.72 (dd, 2H, J_{trans}=18 Hz, J_{cis}=11 Hz); 6.53 (d, 2H, J=2 Hz); 6.43 (t, 1H, J=2 Hz); 5.75 (dd, 2H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.25 (dd, 2H, J_{gem}=1 Hz, J_{cis}=11 Hz); 4.99 (s, 4H); 4.60 (s, 2H); 4.07–4.15 (m, 8H); 3.92–3.86 (m, 8H). ^{13}C NMR, δ: 160.1, 153.1, 143.3, 137.3, 136.8, 136.5, 127.7, 126.4, 115.8, 115.7, 114.0, 105.6, 100.9, 99.4, 70.4, 70.0, 69.9, 68.2, 67.6 and 65.3. MS (EI), *m*/*z*: 732 $(M)^+$HRMS, calcd for $C_{45}H_{48}O_9$ 732.3298, found 732.3329.

3.2.4. 4-(*p*-Vinylphenylmethyloxy)phenol. A mixture of 1,4-hydroquinone (8.8 g, 80 mmol), 4-vinylbenzyl chloride (3.0 g, 20 mmol), potassium carbonate (2.8 g, 20 mmol) and Aliquat 336 (2 mmol) in acetone (75 mL) was placed in a 250 mL round-bottomed flask fitted with a condenser reflux. The reaction mixture was heated for 24 h at 80 °C. The inorganic salts were filtered off and the solvent was evaporated. Chloroform (75 mL) was added to precipitate the excess of 1,4-hydroquinone, which was removed together with the Aliquat 336 by filtration over Florisil. The solvent was evaporated and the crude product was purified by column chromatography (hexane/ethyl acetate, 9:1). Mp: 143–4 °C (ethyl acetate/hexane). Yield 62%. ^{1}H NMR, δ: 7.44 and 7.41 (d, 2H, A_2 of A_2B_2 system, J=8 Hz); 7.39 and 7.36 (d, 2H, B_2 of A_2B_2 system, J=8 Hz); 6.87–6.67 (m, 5H); 5.75 (dd, 1H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.25 (dd, 2H, J_{gem}=1 Hz, J_{cis}=11 Hz); 4.99 (s, 2H). ^{13}C NMR, δ: 153.0, 149.7, 137.3, 136.8, 136.5, 127.7, 126.4, 116.1, 114.0 and 70.5. MS (EI), *m*/*z*: 226 $(M)^+$HRMS, calcd for $C_{15}H_{14}O_2$ 226.0994, found 226.1009.

3.2.5. 1-(Hydroxyethyleneoxyethyleneoxy)-4-(*p*-vinylphenyloxymethyloxy)benzene. A mixture of 4-(*p*-vinylphenylmethyloxy)phenol (2.3 g, 10 mmol), KOH (840 mg, 15 mmol), 2-(2-chloroethoxy)ethanol (1.5 g, 12 mmol) and TBAB (9 mol%) was heated without solvent for 32 h at 80 °C. Acetone was added and the inorganic salts were filtered off. The crude product was purified by column chromatography (hexane/ethyl acetate, 3:1); when the undesired products were carried out, ethyl acetate was used as eluent. The product was obtained as a white solid. Mp: 100–1 °C. Yield 60%. ^{1}H NMR, δ: 7.44 and 7.40 (d, 4H, A_2 of A_2B_2 system, J=8 Hz); 7.39 and 7.35 (d, 4H, B_2 of A_2B_2 system, J=8 Hz); 6.91–6.81 (m, 4H); 6.72 (dd, 2H, J_{trans}=18 Hz, J_{cis}=11 Hz); 5.75 (dd, 2H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.25 (dd, 2H, J_{gem}=1 Hz, J_{cis}=11 Hz); 5.00 (s, 2H); 4.09 (t, 2H, J=4 Hz); 3.83 (t, 2H, J=4 Hz); 3.74 (t, 2H, J=4 Hz); 3.68 (t, 2H, J=4 Hz). ^{13}C NMR, δ: 153.2, 153.0, 137.3, 136.8, 136.5, 127.7, 126.4, 115.9, 115.7, 114.0, 72.5, 70.4, 69.8, 68.1 and 61.8. MS (EI), *m*/*z*: 314 $(M)^+$HRMS, calcd for $C_{19}H_{22}O_4$ 314.1518, found 314.1541.

3.2.6. 1,4-(Bromoethyleneoxyethyleneoxy)(*p*-vinylphenyloxymethyloxy)benzene. In a previously flamed Schlenk tube was placed carbon tetrabromide (5.1 g, 15 mmol), 1,4-(hydroxyethyleneoxyethyleneoxy),(*p*-vinylphenyloxymethyloxy)benzene (1.3 g, 4 mmol) and triphenylphosphine (4.0 g, 15 mmol); dry THF was added (20 mL) and the mixture was stirred at room temperature under Ar atmosphere for 4 h. Triphenylphosphonium oxide formed was filtered off and the solvent was evaporated. The crude product was purified by column chromatography (hexane/ethyl acetate, 8:1). For further purification the product was crystallized from ethanol. Mp: 72–4 °C. Yield 87%. ^{1}H NMR, δ: 7.44 and 7.40 (d, 4H, A_2 of A_2B_2 system, J=8 Hz); 7.39 and 7.35 (d, 4H, B_2 of A_2B_2 system, J=8 Hz); 6.91–6.81 (m, 4H); 6.72 (dd, 2H, J_{trans}=18 Hz, J_{cis}=11 Hz); 5.75 (dd, 2H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.25 (dd, 2H, J_{gem}=1 Hz, J_{cis}=11 Hz); 5.00 (s, 2H); 4.09 (t, 2H, J=4 Hz); 3.91–2.82 (m, 4H); 3.49 (t, 2H, J=6 Hz). ^{13}C NMR, δ:

153.2, 153.0, 137.3, 136.8, 136.5, 127.7, 126.4, 115.9, 115.7, 114.0, 71.4, 70.4, 69.8, 68.2 and 30.2. MS (EI), *m/z*: 376 $(M)^+$, 378 $(M+2)^+$HRMS, calcd for $C_{19}H_{21}BrO_2$ 376.0674, found 376.0651and 378.0670.

3.2.7. 3,5-Bis(*p*-vinylphenylmethyloxy)benzyl bromide (6B). To a solution of **6A** (1.0 g, 2.7 mmol) in the minimum amount of dry THF (10 mL), carbon tetrabromide (1.2 g, 3.38 mmol) and triphenylphosphine (880 mg, 3.38 mmol) were added. The mixture was stirred at room temperature for 20 min. Water (20 mL) was added and the aqueous layer was extracted with methylene chloride (20 mL×3). The combined organic extracts were dried over $MgSO_4$ and evaporated to dryness. The crude product was purified by column chromatography (hexane/ethyl acetate, 3:1) to give the pure product as a white solid. Mp: 78–9 °C. Yield 65%. ^{1}H NMR, δ: 7.44 and 7.40 (d, 4H, A_2 of A_2B_2 system, J=8 Hz); 7.38 and 7.34 (d, 4H, B_2 of A_2B_2 system, J=8 Hz); 6.72 (dd, 2H, J_{trans}=18 Hz, J_{cis}=11 Hz); 6.61 (d, 2H, J=2 Hz); 6.53 (t, 1H, J=2 Hz); 5.76 (dd, 2H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.26 (dd, 2H, J_{gem}=1 Hz, J_{cis}= 11 Hz); 5.02 (s, 4H); 4.41 (s, 2H). ^{13}C NMR, δ: 159.8, 139.6, 137.3, 136.3, 136.0, 127.6, 126.3, 114.1, 108.2, 102.2, 70.0 and 33.6. MS (EI), *m/z*: 434 $(M)^+$, 436 $(M+2)^+$HRMS, calcd for $C_{25}H_{23}BrO_2$ 434.0881, found 434.0894 and 436.0861 (M+2).

3.2.8. 3,5-Bis(*tert*-butyldimethylsilyloxy)benzyl bromide (7B). In a previously flamed Schlenk tube a solution of **7A** (1.104 g, 3 mmol) in dry dichloromethane (15 mL) and dry triethylamine (455 mg, 4.5 mmol) was placed, the mixture was cooled to 0 °C under argon atmosphere. Methanesulfonyl chloride (412 mg, 3.6 mmol) was added dropwise and the reaction was stirred for 30 min. Then, a solution of LiBr (2.60 g, 30 mmol) in dry acetone (17 mL) was added and the reaction was stirred at RT for 3 h. Inorganic salts were filtered off over Celite® 545 and the solvent was evaporated. 15 mL of diethyl ether was added to precipitate the excess of LiBr which was filtered off. The solvent was evaporated and the pure product was isolated as a white solid. Mp: 40–1 °C. Yield 73%. ^{1}H NMR, δ: 6.44 (d, 2H, J=2 Hz); 6.21 (t, 1H, J=2 Hz); 4.30 (s, 2H); 0.93 (s, 18H); 0.15 (s, 12H). ^{13}C NMR, δ: 156.3, 111.5, 111.0, 94.6, 34.0, 25.8, 18.3, −4.2. MS (EI), *m/z*: 430 $(M)^+$, 432 $(M+2)^+$. HRMS, calcd for $C_{13}H_{23}Si_2O_2$ 346.0420, found 346.0448 and 348.0457 (M+2).

3.2.9. 3,5-Bis(*p*-vinylphenylmethyloxy-*p*-phenyloxyethyleneoxyethyleneoxy)benzyl bromide (8B). To a solution of **8A** (2.9 g, 4 mmol) in the minimum amount of dry THF, carbon tetrabromide (1.7 g, 5 mmol) and triphenylphosphine (1.3 g, 5 mmol) were added. The mixture was stirred at room temperature for 20 min. Water (20 mL) was added and the aqueous layer was extracted with methylene chloride (20 mL×3). The combined organic extracts were dried over $MgSO_4$ and evaporated to dryness. The crude product was purified by column chromatography (chloroform) to give the pure product as a white solid. Mp: 66–8 °C. Yield 63%. ^{1}H NMR, δ: 7.44 and 7.40 (d, 4H, A_2 of A_2B_2 system, J=8 Hz); 7.38 and 7.34 (d, 4H, B_2 of A_2B_2 system, J=8 Hz); 6.91–6.81 (m, 8H); 6.72 (dd, 2H, J_{trans}=18 Hz, J_{cis}=11 Hz); 6.53 (d, 2H, J=2 Hz); 6.43 (t, 1H, J=2 Hz); 5.75 (dd, 2H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.25 (dd, 2H, J_{gem}=1 Hz, J_{cis}=11 Hz); 4.99 (s, 4H); 4.38 (s, 2H); 4.15–4.07 (m, 8H); 3.92–3.86 (m, 8H). ^{13}C NMR, δ: 160.1, 153.3, 139.9, 137.5, 137.1, 136.7, 127.9, 126.7, 116.2, 116.0, 114.3, 108.4, 105.9, 102.2, 70.9, 70.5, 70.2, 68.6, 68.1 and 34.0. HRMS (L-SIMS), *m/z* calcd for $C_{45}H_{47}BrO_8$ 794.2454, found 794.2441 $(M+H)^+$and 796.2456 $(M+H+2)^+$.

3.3. Preparation of dendrimers

General procedure for dendrimers with ester connectivity. In a previously flamed Schlenk tube, equimolar amounts of the corresponding dendron and 4-dimethylaminopyridine under Ar atmosphere were dissolved in dry dichloromethane (3 mL/mmol). 1,3,-benzenetricarboxylic acid chloride (33 mol%) was added dropwise. The reaction was stirred at room temperature for 4 h. The 4-dimethylaminipyridium chloride formed was filtered off and the solvent was evaporated. Pure products were purified as indicated below.

3.3.1. 3,5-Bis(phenylmethyloxy)phenylmethyl 1,3,5-benzenetricarboxylate (10). The pure product was obtained as a with solid after crystallization from ethyl acetate/hexane. Mp: 112–4 °C. Yield 1.83 g, 94%. ^{1}H NMR, δ: 8.90 (s, 3H); 7.41–7.28 (m, 30H); 6.68 (t, 3H, J=2 Hz); 6.58 (t, 3H, J=2 Hz); 5.34 (s, 6H); 5.01 (s, 12H). ^{13}C NMR, δ: 164.7, 160.1, 137.7, 136.6, 134.9, 131.2, 128.6, 128.0, 127.5, 107.3, 102.0, 70.1 and 67.2. MS (MALDI-TOF), *m/z*: 1139.3 $(M+Na)^+$.

3.3.2. 3,5-Bis(*p*-bromophenylmethyloxy)phenylmethyl 1,3,5-benzenetricarboxylate (12). The pure product was obtained as a white solid after crystallization from ethyl acetate/hexane. Mp: 149–51 °C. Yield 842 mg, 95%. ^{1}H NMR, δ: 8.90 (s, 3H); 7.47 and 7.45 (d, 12H, A_2 of A_2B_2 system, J=8 Hz); 7.26 and 7.24 (d, 12H, B_2 of A_2B_2 system, J=8 Hz); 6.65 (d, 6H, J=2 Hz); 6.51 (t, 3H, J=2 Hz); 5.35 (s, 6H); 4.97 (s, 12H). ^{13}C NMR, δ: 164.4, 159.6, 137.7, 135.5, 134.7, 131.5, 131.0, 128.9, 121.8, 107.3, 102.0, 69.3 and 67.1. MS (MALDI-TOF)), *m/z*: 1612.9 $(M+Na+6)^+$(100), 1614.9 $(M+H+8)^+$(86).

3.3.3. 3,5-Bis(*p*-vinylphenylmethyloxy)phenylmethyl 1,3,5-benzenetricarboxylate (13). The pure product was obtained as a white solid after crystallization from ethyl acetate/hexane. Mp: 113–5 °C. Yield 1.36 g, 90%. ^{1}H NMR, δ: 8.90 (s, 3H); 7.39 and 7.36 (d, 12H, A_2 of A_2B_2 system, J=8 Hz); 7.35 and 7.32 (d, 12H, B_2 of A_2B_2 system, J=8 Hz); 6.73–6.63 (m, 12H); 6.56 (t, 3H, J=2 Hz); 5.72 (dd, 6H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.33 (s, 6H); 5.23 (dd, 6H, J_{gem}=1 Hz, J_{cis}=11 Hz); 5.00 (s, 12H). ^{13}C NMR, δ: 167.6, 160.1, 137.7, 136.4, 136.1, 134.9, 131.2, 127.7, 126.4, 114.1, 107.3, 102.1, 69.9 and 67.2. MS (MALDI-TOF), *m/z*: 1295.5 $(M+Na)^+$.

3.3.4. 3,5-Bis(*tert*-butyldimethylsilyloxy)benzyl 1,3,5-benzene tricarboxylate (15). The crude of the reaction was dissolved in CH_2Cl_2 (20 mL) and washed with water (15 mL x 3). The organic layer was dried over $MgSO_4$ and filtered over silica to remove the excess of DMAP. After evaporation of the solvent the pure product was isolated as a white solid. Mp: 91–3 °C. Yield 73%. ^{1}H NMR, δ: 8.89 (s, 3H) 6.53 (d, 6H, J=2 Hz); 6.29 (t, 3H, J=2 Hz); 5.28 (s, 6H); 0.96 (s, 54H); 0.18 (s, 36H). ^{13}C NMR, δ: 164.7,

156.7, 137.4, 134.8, 131.4, 113.3, 112.1, 67.2, 26.0, 18.5 and −4.0. MS (MALDI-TOF), *m/z*: 1283.3 $(M+Na)^+$.

3.3.5. 3,5-Bis(*p*-vinylphenylmethyloxy-*p*-phenyloxyethylene-oxyethyleneoxy)phenylmethyl 1,3,5-benzenetricarboxylate (14). The pure product was obtained after crystallization from dichloromethane/ethanol. Mp: 52–5 °C. Yield 413 mg, 63%. ^{1}H NMR, δ: 8.87 (s, 3H); 7.43 and 7.39 (d, 12H, A_2 of A_2B_2 system, J=8 Hz); 7.37 and 7.33 (d, 12H, B_2 of A_2B_2 system, J=8 Hz); 6.73 (dd, 6H, J_{cis}=11 Hz, J_{trans}=18 Hz); 6.59 (d, 6H, J=2 Hz); 6.48 (t, 3H, J=2H); 5.74 (dd, 6H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.28 (s, 6H); 5.25 (dd, 6H, J_{gem}=1 Hz, J_{cis}=11 Hz); 4.97 (s, 12H); 4.09 (m, 24H); 3.87 (m, 24H). ^{13}C NMR, δ: 164.6, 160.1, 153.1, 137.6, 137.2, 136.8, 136.4, 134.9, 131.2, 127.6, 126.3, 115.8, 115.6, 114.0, 107.1, 101.6, 99.4, 70.4, 70.0, 69.8, 68.1, 67.6 and 67.2. MS (MALDI-TOF), *m/z*: 2375.7 $(M+Na)^+$.

3.3.6. (3,5-Dihydroxyphenyl)methyl 1,3,5-benzenetricarboxylate (11). 3,5-Bis(phenylmethyloxy)phenylmethyl 1,3,5-benzenetricarboxylate (1.1 g, 1 mmol) and palladium over carbon (6 mol%) was suspended in dimethoxyethane (20 mL) and the reaction mixture was stirred at room temperature under H_2 atmosphere until the expected volume of H_2 was consumed. Palladium over carbon was filtered off over Celite 545® and the solvent was evaporated. The pure product was obtained as a pale brown solid. Mp: 226–8 °C. Yield 100%. ^{1}H NMR, δ (d_6-DMSO): 8.85 (s, 3H); 6.48 (d, 6H, J=2 Hz); 6.33 (t, 3H, J=2H); 5.30 (s, 6H); 3.17 (s, 6H). ^{13}C NMR, δ (d_6-DMSO): 165.1, 159.6, 138.8, 134.7, 132.4, 107.2, 103.3 and 67.8. MS (FAB^+), *m/z*: 576 (M^+).

3.3.7. General procedure for dendrimers with ether connectivity (Williamson conditions). 3B or **5B** (4.2 mmol), **3** (384 mg, 1 mmol), 18-crown-6 (10% mol), potassium carbonate (580 mg, 4.2 mmol) and acetone (20 mL) were placed in a round-bottomed flask, and the reaction mixture was heated at 70 °C for 24 h. The solvent was evaporated and 20 mL of water were added. The reaction was extracted with chloroform (20 mL×3).

3.3.8. Tetrakis[(3,5-bis(*p*-vinylphenylmethyloxy)phenylmethyloxyphenyl]methane (18). After column chromatography (chloroform) the pure product was obtained as a pale brown solid. Mp: 78–80 °C. Yield 954 mg, 53%. ^{1}H NMR, δ: 7.43 and 7.40 (d, 16H, A_2 of A_2B_2 system, J= 8 Hz); 7.38 and 7.35 (d, 16H, B_2 of A_2B_2 system J=8 Hz); 6.84 and 6.80 (d, 8H, A_2 of A_2B_2 system, J=8 Hz), from 6.72–6.60 (m, 24H); 6.53 (t, 4H, J=2 Hz); 5.76 (dd, 8H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.26 (dd, 8H, J_{gem}=1 Hz, J_{cis}=11 Hz); 5.02 (s, 16H); 4.95 (s, 8H). ^{13}C NMR, δ: 159.8, 156.5, 139.9, 139.6, 137.3, 136.3, 136.0, 131.7, 127.6, 126.3, 114.1, 113.8, 108.2, 102.2, 70.6, 70.0 and 61.6. MS (MALDI-TOF), *m/z*: 1823.8 $(M+Na)^+$.

3.3.9. Tetrakis[(3,5-bis(*p*-vinylphenylmethyloxy-*p*-phenyloxyethyleneoxyethyleneoxy)phenylmethyloxyphenyl] methane (19). After column chromatography (chloroform) the pure product was obtained as a pale yellow solid. Mp: 62–4 °C. Yield 1.4 g, 43%. ^{1}H NMR, δ: 7.44 and 7.40 (d, 16H, A_2 of A_2B_2 system, J=8 Hz); 7.38 and 7.34 (d, 16H, B_2 of A_2B_2 system, J=8 Hz), 7.05 (d, 8H, A_2 of A_2B_2 system (core), J=8 Hz); 6.86–6.63 (m, 48H); 6.58 (d, 8H, J=2 Hz); 6.44 (t, 4H, J=2 Hz); 5.75 (dd, 8H, J_{gem}=1 Hz, J_{trans}=18 Hz); 5.25 (dd, 8H, J_{gem}=1 Hz, J_{cis}=11 Hz); 4.96 (s, 16H); 4.91 (s, 8H); 4.08 (m, 32H); 3.87 (m, 32H). ^{13}C NMR, δ: 159.9, 156.5, 153.0, 139.8, 139.4, 137.1, 136.7, 136.3, 131.9, 131.7, 127.5, 126.2, 115.8, 115.6, 113.9, 113.5, 106.2, 101.2, 99.5, 70.5, 70.1, 69.9, 68.2, 67.6 and 64.8. MS (MALDI-TOF), *m/z*: 3264.1 $(M+Na)^+$.

3.4. Dendrimers with ether connectivity (Mitsunobu conditions)

3.4.1. 1,3,5-Tris[3,5-bis(*p*-bromophenylmethyloxy)phenylmethyloxy]benzene (16). In a previously flamed Schlenk a mixture of phloroglucinol (126 mg, 1 mmol), **5A** (2.4 g, 5 mmol) and triphenylphosphine (1.1 g, 4 mmol) was dissolved in dry THF (15 mL) under argon atmosphere. A solution of DEAD (695 mg, 4 mmol) in dry THF (5 mL) was added dropwise and the reaction was stirred at room temperature overnight. The solvent was evaporated and diethyl ether was added to precipitate the desired compound with a little amount of triphenylphosphine, the crude product was purified by crystallization from ethyl acetate/carbon tetrachloride. Mp: 152–3 °C. Yield 70%. ^{1}H NMR, δ: 7.49 and 7.47 (d, 12H, A_2 of A_2B_2 system, J=8 Hz); 7.27 and 7.25 (d, 12H, B_2 of A_2B_2 system, J=8 Hz); 6.63 (d, 6H, J=2 Hz); 6.49 (t, 3H, J=2 Hz); 6.20 (s, 3H); 4.97 (s, 12H); 4.93 (s, 6H). ^{13}C NMR, δ: 160.4, 159.8, 139.3, 135.6, 131.7, 129.1, 122.0, 106.4, 101.5, 94.8, 69.8 and 69.3. MS (L-SIMS), *m/z*: 1506.89 $(M+H+6)^+$(100), 1508.89 $(M+H+8)^+$(85).

3.4.2. 1,3,5-Tris[3,5bis(*tert*-butyldimethylsilyloxy)benzyloxy]benzene (17). In a previously flamed Schlenk a mixture of phloroglucinol (88 mg, 0.7 mmol), **7A** (1.0 g, 2.8 mmol) and triphenylphosphine (642 mg, 2.45 mmol) was dissolved in dry THF (20 mL) under argon atmosphere. A solution of DEAD (427 mg, 2.45 mmol) in dry THF (5 mL) was added drop wise and the reaction was stirred at room temperature overnight. The solvent was evaporated and the crude product was purified by column chromatography (hexane). The product was isolated as a white solid. Mp: 74–6 °C. Yield 35%. ^{1}H NMR, δ: 6.52 (d, 6H, J=2 Hz); 6.28 (t, 3H, J=2 Hz); 6.22 (s, 3H); 4.88 (s, 6H); 4.93 (s, 6H); 0.98 (s, 54H); 0.19 (s, 36H). ^{13}C NMR, δ: 160.5, 156.6, 138.8, 112.3, 101.4, 95.1, 69.8, 25.7, 18.2 and −4.4. MS (MALDI-TOF), *m/z*: 1215.7 $(M+Na)^+$.

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