A Series of First- and Second-Generation Dendronized Polymers with Orthogonally Protected Amine Groups in the Periphery

Rabie Al-Hellani and A. Dieter Schlüter*

Institute of Polymers, Department of Materials, ETH Zürich, CH-8093 Zürich-Hönggerberg, Wolfgang-Pauli-Str. 10, HCI J 541, Switzerland

Received August 24, 2006; Revised Manuscript Received October 18, 2006

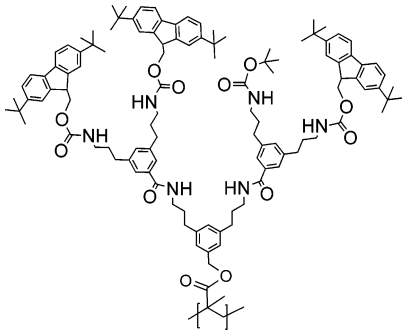
ABSTRACT: The synthesis of high molar mass first- and second-generation dendronized polymers is described which carry a predetermined number of Fmoc* and Boc protected peripheral amine groups at each repeat unit. Together with the corresponding fully Boc protected polymers which are already known, dendronized polymers with the following surface decorations are now available on the G1 (Boc:Fmoc* = 100:0, 50:50, 0:100) and G2 level (Boc:Fmoc* = 100:0, 75:25, 50:50, 25:75). The orthogonality of these groups was proven on the polymer level, where easily hundreds of them are concerned per macromolecule.

Introduction

Dendronized polymers are an established class of comb polymers.[1,2] Each repeat unit carries a regularly branched substituent, a so-called dendron, rather than a linear one, which is normally the case for such polymers. Depending on their size (generation), these dendrons not only have impact on the backbone conformation and mobility but also allow to introduce a large number of functional groups. This enables engineering the properties of dendronized polymers in a wide range.[2] Almost all dendronized polymers known today carry only one kind of functional group (mostly either amine or hydroxyl) which are typically uniformly protected with only one kind of protecting group. Typical examples are those which carry exclusively *tert*-butyloxycarbonyl (Boc) protected amine groups as the peripheral functional units.[2] This limits the options for "surface" engineering to modify either all amines at once or a certain amount of them randomly distributed over the entire macromolecule. A site selective attachment of, e.g., two different entities is therefore not possible. A while ago a project was started to overcome this limitation and thus increase the options for surface decoration by the development of dendronized macromonomers and polymers which carry defined and variable proportions of orthogonally protected peripheral amine groups at each repeat unit.[3] Selective deprotection should then allow for introducing predetermined numbers of entities to each repeat unit. In the project's initial phase, Boc and benzyloxycarbonyl (Cbz) groups were tried which are known to be orthogonal from low molar mass chemistry. They were found to be in fact orthogonal even when attached to dendrons in larger numbers.[4] When finally applied to dendronized polymers of high molar mass, however, it was almost impossible to quantitatively and reproducibly remove Cbz irrespective of the numerous conditions tried.[4] It was therefore decided to try the combination 2,7-di(*tert*-butyl)-9-fluorenyloxycarbonyl (Fmoc*) and Boc instead. This paper describes the synthesis of a set of first (G1) and second generation (G2) dendronized methacrylate-based macromonomers with varying ratios of Fmoc* and Boc protected amine groups, their polymerization into high molar mass G1 and G2 dendronized polymers (for an example, see Chart 1), respectively, and the selective deprotection of both protecting groups on the polymer level leaving the respective other untouched.

* Corresponding author. E-mail: dieter.schluter@mat.ethz.ch.

Chart 1. Chemical Structure of One of the Target Polymers on the Second Generation Level[a]



[a] Its four terminal amine groups are orthogonally protected by three Fmoc* groups and one Boc group which, after selective deprotection, allows addressing 75% and 25% of the amines independently from one another.

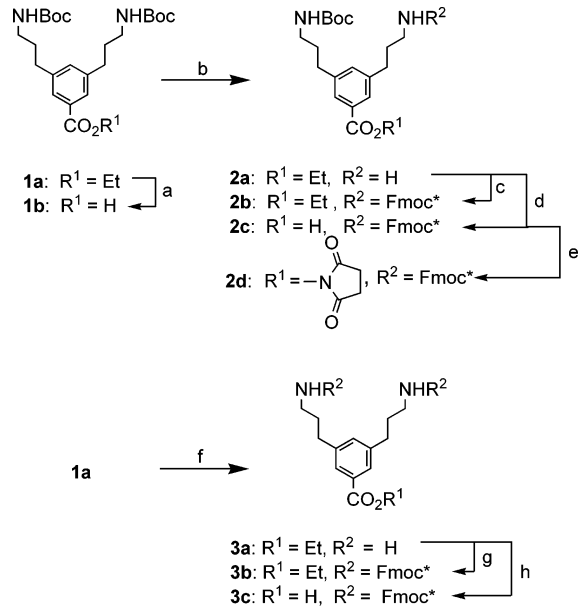
This work can be seen as part of a greater effort to master systematic synthetic modifications on man-made polymers and biomacromolecules of considerable complexity.[5]

Results and Discussion

There are many protecting groups for amines,[6] the orthogonality of which was most convincingly shown for the combinations Cbz/Boc and 9-fluorenylmethyleneoxycarbonyl (Fmoc)/Boc. As mentioned above, the first combination met with some problems related to Cbz. Fmoc/Boc was therefore a natural next choice. For the present study Fmoc was nevertheless not considered ideal because of serious concerns regarding the solubility of dendronized polymers carrying a high load of these relatively flat and conformationally rigid units at the macromolecule's "surface".[7] Orienting studies showed, in fact, a dramatic and intolerable decrease of the solubility of Fmoc decorated dendronized polymers in solvents like chloroform, toluene, and THF in which these polymers otherwise tend to be highly soluble.[8] With this in mind a derivative of Fmoc, Fmoc*,[9] was used. With its two *tert*-butyl groups a higher solubility was to be expected and actually also reported.[9] Additionally, there was an easy procedure for the synthesis of an attractive Fmoc* precursor, the Fmoc* succinimidyl active ester, in the literature which allows its 20 g scale preparation via three steps and at very low cost.[9] There was however one

10.1021/ma061957a CCC: $33.50
Published on Web 12/01/2006

Scheme 1[a]

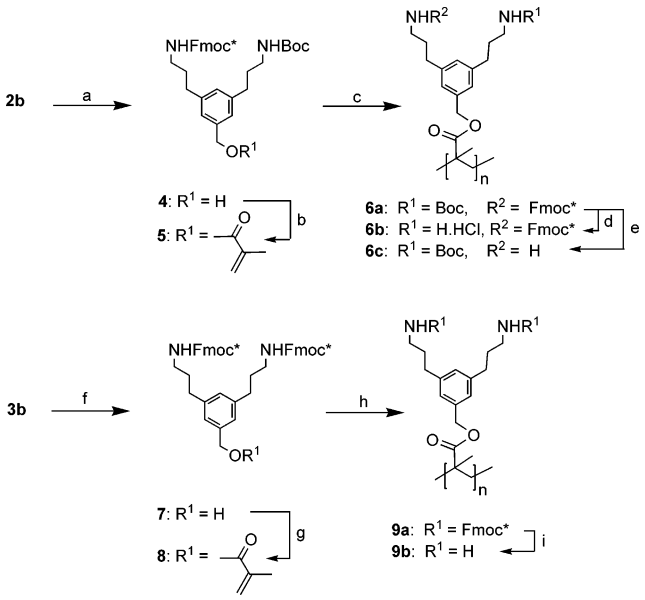


[a] Reagents and conditions: (a) **1a**, KOH, THF/MeOH/H_2O, 55 °C, 6 h (92%); (b) **1a**, CF_3COOH, CH_2Cl_2, rt, 48 h (62%); (c) **2a**, (2,7-di-*tert*-butyl-9-fluorenyl)methyl 2,5-dioxopyrrolidin-1-yl carbonate, DIEA, CH_2Cl_2 (89%); (d) 1. **2a**, KOH, THF/MeOH/H_2O, 55 °C, 6 h, 2. (2,7-di-*tert*-butyl-9-fluorenyl)methyl 2,5-dioxopyrrolidin-1-yl carbonate, DIEA, CH_2Cl_2, rt, 14 h (75%); (e) **2c**, HOSu, DCC, CH_2Cl_2, rt, 14 h (81%); (f) **1a**, CF_3COOH, CH_2Cl_2, rt, 6 h (95%); (g) **3a**, (2,7-di-*tert*-butyl-9-fluorenyl)methyl 2,5-dioxopyrrolidin-1-yl carbonate, DIEA, CH_2Cl_2 (95%); (h) 1. **3a**, KOH, THF/MeOH/H_2O, 55 °C, 6 h, 2. (2,7-di-*tert*-butyl-9-fluorenyl)methyl 2,5-dioxopyrrolidin-1-yl carbonate, DIEA, CH_2Cl_2, rt, 14 h (94%).

potential disadvantage with the anticipated combined use of Fmoc* and Boc. Both carry *tert*-butyl groups which in the worst case could absorb more or less isochronically in the ^{1}H NMR spectrum. This would render a quick and easy determination of degrees of selective deprotection by NMR integration difficult or even impossible. It was nevertheless decided to follow the approach and to rather apply other quantification methods if this worst case became real.

Schemes 1 and 2 delineate all syntheses and polymerizations on the G1 level, whereas Schemes 3, 4, and 5 exhibit the same on the G2 level. Schemes 2−5 also contain all deprotections on the polymer level. Because of their importance for the entire project, the deprotections will be described jointly after all other synthetic aspects have been dealt with. Starting material **1a** was prepared on the 150 g scale according to literature procedures[10] and subjected to a desymmetrization step already at an early stage of the entire sequence. Treatment with 3 equiv of trifluoroacetic acid for 2 days at room temperature gave compound **2a**, which still carries one Boc protected amine. It was isolated on the 20 g scale and in a yield of 65%. Most of the other product was unchanged starting material which could be recovered and reused. The introduction of Fmoc* was done according to conventional procedures whereby the active ester derivative[8] proved to be superior in terms of less byproducts to the originally reported chloroformate.[9] This active ester was therefore used in all other introductions of Fmoc* throughout the present work. It cleanly gave **2b**, which after focal point reduction was used for the synthesis of G1 macromonomer **5** (Scheme 2). Compound **2c** which is an important building block for the synthesis of various G2 dendrons could not be directly synthesized from **2b** because focal point saponification led to partial removal of Fmoc*. Therefore, ester **2a** was saponified and the resulting carboxylic acid then subjected to Fmoc*

Scheme 2[a]



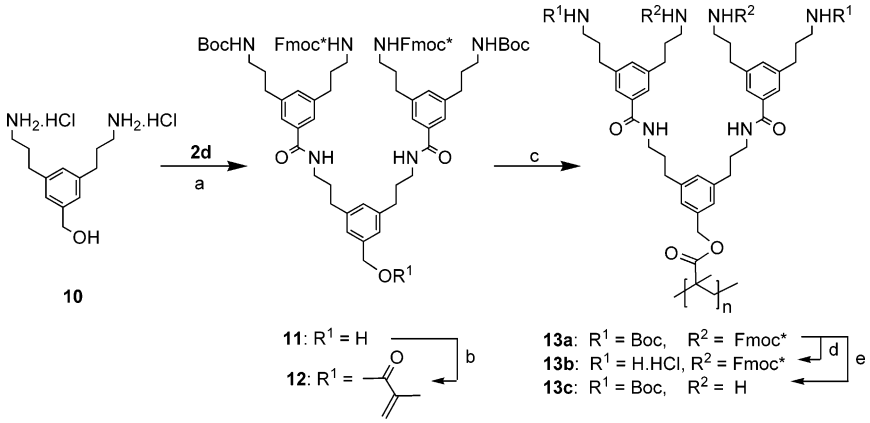
Reagents and conditions: (a) **2b**, 2 M LiBH4, THF, rt, 14 h (92%); (b) **4**, MAC, DIEA, DMAP, CH_2Cl_2, rt, 14 h (94%); (c) **5**, DMF, 70 °C, 20 h, (65%); (d) **6a**, 25% HCl, THF, 14 h (96%); (e) **6a**, 25% piperidine, DMF, 48 h; (f) **3b**, 2 M LiBH4, THF, rt, 14 h (87%); (g) **7**, MAC, DIEA, DMAP, CH_2Cl_2, rt, 14 h (78%); (h) **8**, DMF, 70 °C, 18 h (63%); (i) **9a**, 25% piperidine, DMF, 48 h (85%).

succinimidyl active ester to give **2c** on the 2 g scale and in a yield of 90−95% over the two steps. This compound was then transformed into the dendron active ester **2d** by standard protocols.[10] The dendron **3b** with its two Fmoc* protected amines was easily obtained from **1a** by exchanging Boc by Fmoc* on the 2 g scale. Dendron **3b** after focal point reduction was used for the synthesis of G1 macromonomer **8**. Building block **3c** was obtained from **3a** by focal point saponification and subsequent introduction of two Fmoc*'s. Scheme 2 describes how the G1 methacrylate macromonomers with the protecting group patterns Fmoc*/Boc (**5**) and Fmoc*/Fmoc* (**8**) were accessed. It is worth mentioning in this context that the reduction of **2b** and **3b** required the use of lithium borohydride instead of lithium aluminum hydride if attack of Fmoc* was to be avoided. The polymerizable units were attached to the alcohols **4** and **7** by using freshly distilled methacrylic acid chloride, which is an important point whenever high molar masses of the corresponding polymers are concerned. The polymerizations occurred without addition of initiator precursors by placing the flasks containing the highly concentrated solutions of monomers in DMF into preheated oil baths (70 °C). The yields and molar masses are summarized in Table 1. The molar masses were determined by GPC using two angle light scattering and viscosity detection. PMMA was used as internal standard.

Scheme 3 describes the synthesis of G2 polymer **13a** which carries two Boc's and two Fmoc*'s. The sequence starts from the known branching unit **10**[10] which was reacted with 2.4 equiv of **2d** to give the G2 dendron **11**. This dendron was converted into macromonomer **12** which was then polymerized as described above. Schemes 4 and 5 show analogous sequences which led to polymers **18a** and **23a** with their 3 Boc's and 1 Fmoc* and 3 Fmoc*'s and 1 Boc, respectively.

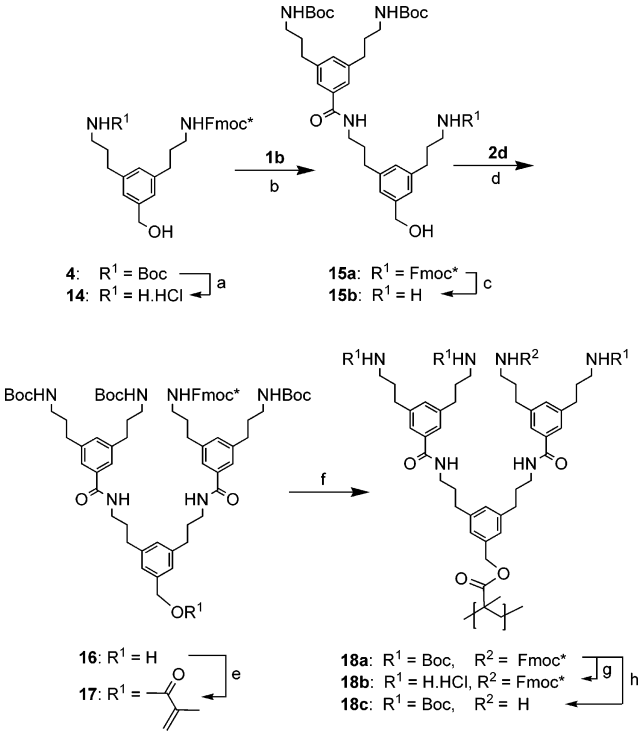
Together with the known G1 and G2 polymers **24** and **25** (Chart 2)[10] which have exclusively Boc protected peripheral amine groups, the polymers **6a**, **9a**, **13a**, **18a**, and **23a** described above form a complete set of dendronized polymers in which the Boc and Fmoc* protecting groups are systematically varied.

Scheme 3[a]



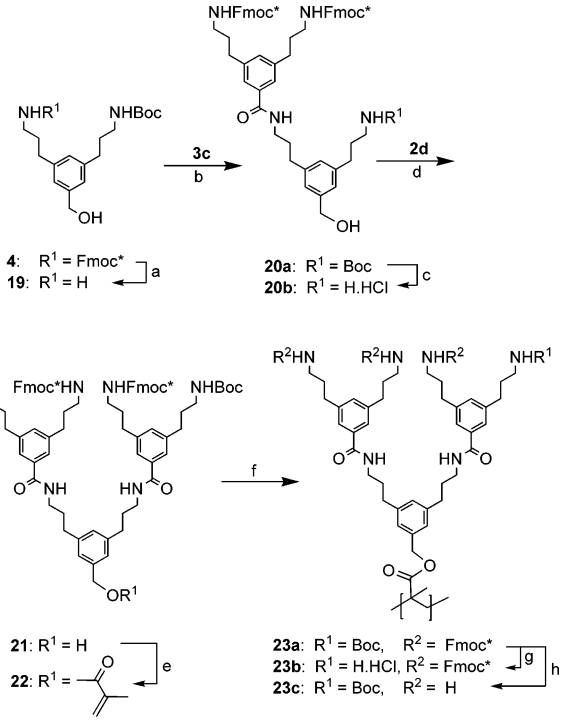
[a] Reagents and conditions: (a) **10**, DIEA, MeOH, CH_2Cl_2, **2d**, rt, 14 h (86%); (b) **11**, MAC, DIEA, DMAP, CH_2Cl_2, rt, 14 h (77%); (c) **12**, DMF, 70 °C, 22 h (83%); (d) **13**a, 25% HCl, THF, 14 h (94%); (e) **13a**, 25% piperidine, DMF, 48 h (91%).

Scheme 4[a]



[a] Reagents and conditions: (a) **4**, 25% HCl, THF, 3 h (94%); (b) **1b**, CH_2Cl_2, HOBt, EDC, **14**, DIEA, 14 h, rt (82%); (c) **15a**, 20% piperidine, DMF, 14 h (95%); (d) **15b**, DIEA, MeOH, CH_2Cl_2, **2d**, 14 h, rt (87%); (e) **16**, MAC, DIEA, DMAP, CH_2Cl_2, 14 h, rt (95%); (f) **17**, DMF, 70 °C, 20 h, (75%); (g) **18a**, 25% HCl, THF, 14 h (92%); (h) **18a**, 25% piperidine, DMF, 48 h (82%).

Scheme 5[a]



[a] Reagents and conditions: (a) **4**, 20% piperidine, DMF, 14 h (94%); (b) **3c**, CH_2Cl_2, HOBt, EDC, **19**, DIEA, 14 h, rt (83%); (c) **20a**, 25% HCl, THF, 3 h (98%); (d) **20b**, DIEA, MeOH, CH_2Cl_2, **2d**, 14 h, rt (90%); (e) **21**, MAC, DIEA, DMAP, CH_2Cl_2, 14 h, rt (87%); (f) **22**, DMF, 70 °C, 10 h (83%); (g) **23a**, 25% HCl, THF, 14 h (85%); (h) **23a**, 25% piperidine, DMF, 48 h (85%).

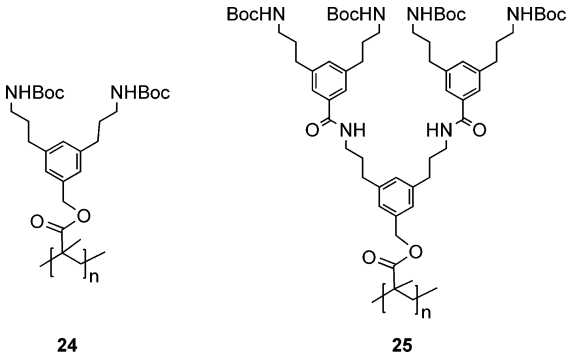
As next it was explored whether these groups are truly orthogonal to one another even when hundreds or thousands of them are on the same macromolecule. As described for other dendronized polymers, the deprotection of Boc was done in THF solutions with 25% aqueous HCl at room temperature, the one of Fmoc* in DMF solution with 25% aqueous piperidine in DMF at room temperature for 2 days. The 2,7-di-*tert*-butyldibenzofulvene derivative that formed during the latter deprotection was removed by extracting it into hexane. For recovery by precipitation the free amine groups of the Fmoc*-deprotected polymers were protonated by the application of 0.1 N HCl. Otherwise, redissolving of a once-dried polymer was difficult.

A rigorous quantification of the respective degrees of deprotection was difficult to achieve. In the ^{1}H NMR spectra an unfavorable signal overlap was observed between the (only) signal of Boc and the *tert*-butyl signal of Fmoc*. Thus, whereas the disappearance of Fmoc* showed in the decreased intensity of several signals, the one of Boc showed in the decreased intensity of a signal superimposed by Fmoc*. This together with

Table 1. Monomer Concentrations, Polymerization Times, Polymer Yields, and Polymer Molar Masses of the Polymerizations of Macromonomers 5, 7, 12, 17, and 22 in DMF at 70 °C without Initiator Precursors Added

monomer	[M] (mol/L)	time (h)	yield (%)	$M_n \times 10^5$ (g/mol)	PDI
5	4.6	16	75	9.5	3.3
7	3.7	16	59	2.4	2.1
12	2.3	22	83	5.4	2.1
17	3.9	20	75	7.2	2.5
22	2.2	10	83	1.9	2.0

Chart 2. Structures of 24 and 25



the considerable line widths and some contamination with water rendered NMR integration too unreliable to be used for that purpose. The deprotection degree could however be reasonably well assessed by ^{13}C NMR spectroscopy. Highly concentrated solutions of all protected and partially deprotected polymers were measured until at least 30 000 pulses had been accumulated. A representative series of spectra are shown for polymers **13a**−**13c** (Figure 1). In the spectrum of the fully protected G2 polymer **13a** the signals of both protecting groups can be seen clearly. For the assessment special attention was given to the pair of *tert*-butyl signals of each protecting group which absorbed at rather different chemical shifts (Fmoc*: $\delta = 31.7$ (CH_3) and 34.9 (C_{quat}); Boc: $\delta = 28.6$ (CH_3) and 79.8 (C_{quat}). Parts b and c of Figure 1 show the spectra of the Boc-deprotected **13b** and the Fmoc* deprotected **13c**, respectively. The corresponding signals disappeared quantitatively.[11] There are a few further important observations to be mentioned. In the experiments aiming at deprotection of Boc only deprotected products of Boc were observed and none of a possible deprotection of Fmoc*.[12] Obviously, the Fmoc* groups remained unaffected. On the other side of the token, the Fmoc*-deprotected polymer **13c** did not show any remaining fluorescence, which indicates that all Fmoc* groups had, in fact, been removed completely. Analogous evidence for the level of orthogonality was obtained for all other polymers. Together with the substantial and rigorous evidence that Boc can be quantitatively removed in closely related polymers carrying exclusively Boc protected amines,[10,13] it is concluded that also in the cases described here both protecting groups can be selectively removed without mutual interference. It should be mentioned that the deprotections cause some shift changes which makes interpretation of the spectra in Figure 1 more complicated. This refers specifically to the α-CH_2 shifts which absorb between $\delta = 29.00$ and 35.00 ppm depending upon whether they carry a protecting group or not. The spectrum in Figure 1b has much broader signals than the other two, which is attributed to its reduced solubility and increased aggregation tendency in the NMR solvent ($CDCl_3/CD_3OD$).

The set of orthogonally protected dendronized polymers described here opens the way to a systematic exploration of "surface" modifications for this class of polymers and their impact on properties. Since dendronized polymers under certain conditions are macromolecular objects with cylindrical shape, the present work can also be considered as a rational property engineering of complex nanocylinders. Such an endeavor will not only reach far into the materials sciences but also into the bio world. Compounds derived from or similar to those described here will also have a future in regard to single molecule chemistry at interfaces which may turn useful for the so-called bottom-up approach to the nanosciences.[13]

Experimental Part

Syntheses. Dendrons **1a**, **1b**, **3a**, and **10** were prepared according to literature procedures.[10] Reagents were purchased from Aldrich, Acros, or Fluka. Methacryloyl chloride (MAC) was freshly distilled before use. Tetrahydrofuran (THF) was refluxed over Na with benzophenone as indicator; dichloromethane (CH_2Cl_2) was dried by distilling over CaH_2. All other reagents and solvents were used as received. All reactions were performed under a nitrogen atmosphere. Silica gel 60 M (Macherey-Nagel, 0.04−0.063 mm/230−400 mesh) was used as the stationary phase for column chromatography. ^1H and ^{13}C NMR spectra were recorded on Bruker AM 300 (^1H: 300 MHz; ^{13}C: 75 MHz), AV 500 (^1H: 500 MHz; ^{13}C: 125 MHz), and AV 700 (^1H: 700 MHz) spectrometers at room temperature and at 50 °C in the case of polymers using chloroform-*d* or methanol-d_4 as a solvent. High-resolution MALDI analyses were performed by the MS service of the Laboratorium für Organische Chemie, ETH Zürich, on an IonSpec Ultra instrument. Elemental analyses were performed by the Mikrolabor of the Laboratorium für Organische Chemie, ETH Zürich. The samples were dried rigorously under vacuum prior to analysis to remove strongly adhering solvent molecules. Gel permeation chromatography (GPC) measurements were carried out using PL-GPC 220 instrument with 2× PL-Gel Mix-B LS column set (2 × 30 cm) equipped with RI (refractive index), viscosity, and LS (light scattering with 15° and 90° angles) detectors (DMF + 1 g L^{-1} LiBr as eluent at 80 °C). Universal calibration was done using PMMA standards in a range of $M_p = 2680$ to 3 900 000 (Polymer Labs. Ltd, UK).

General Procedure for Monomer Synthesis. (Procedure A). MAC (1.5 equiv) in CH_2Cl_2 was added dropwise to a solution of the respective dendron with alcohol focal point, DIEA (2 equiv), and DMAP (catalytic amount) in CH_2Cl_2 at 0 °C. The resulting mixture was stirred overnight at room temperature (rt). After washing with $NaHCO_3$ and brine, the solvent was removed at rt, and the monomer was purified with column chromatography.

General Procedure for Polymerization (Procedure B). Into a Schlenk tube was added the monomer and solvent. The mixture was stirred until it turned homogeneous (few minutes). The concentration of the monomer was kept around 75% (w/w). The mixture was immediately degassed by several freeze−pump−thaw cycles and then kept at 70 °C for a predetermined time. After polymerization, the polymer was dissolved in CH_2Cl_2 and purified by column chromatography (silica gel, CH_2Cl_2 as eluent).

General Procedure for Boc Deprotection of Polymers (Procedure C). 25% HCl (8 equiv per amine group) in THF was added dropwise to a solution of the respective polymer in THF at 0 °C. The resulting mixture was stirred at rt overnight. The solvent was evaporated, and the polymer was dried in high vacuum.

General Procedure for Fmoc* Deprotection of Polymers (Procedure D). 25% aqueous piperidine (20 equiv per amine group) in DMF was added dropwise to a solution of the respective polymer in DMF at 0 °C. The resulting mixture was stirred at rt for 48 h. It was then washed with hexane, and the free amine was protonated by adding 0.1 N HCl. After evaporation of the solvent, the polymer was dissolved in MeOH and precipitated in diethyl ether.

Ethyl-3-[3-(amino)propyl]-5-[3-(*tert*-butyloxycarbonylamino)-propyl] Benzoate (2a). CF_3COOH (7.5 mL, 3.2 equiv) in CH_2Cl_2 (130 mL) was added to a solution of **1a** (14.0 g, 30 mmol) in CH_2Cl_2 at 0 °C. The mixture was stirred at rt for 48 h, and the solvent was then evaporated. Chromatographic separation (silica gel, CH_2Cl_2/MeOH/Et_3N: v/v: 10/1/0.1) yielded **2a** (6.8 g, 62%) as a brown viscous oil. ^1H NMR ($CDCl_3/CD_3OD$): δ 1.37 (t, 3 H, CH_3), 1.40 (s, 9 H, CCH_3), 1.75 (m, 2 H, CH_2), 1.99 (m, 2 H, CH_2), 2.62 (t, 2 H, CH_2Ph), 2.68 (t, 2 H, CH_2Ph), 2.99 (q, 2 H, CH_2NH), 3.12 (q, 2 H, CH_2NH), 4.32 (q, 2 H, CH_2O), 4.71 (s, br, 1 H, NH), 7.17 (s, 1 H, ArH), 7.62 (s, 1 H, ArH), 7.66 (s, 1 H, ArH), 8.24 (s, br, 2 H, NH). ^{13}C NMR ($CDCl_3/CD_3OD$): δ 14.23, 28.34, 28.68, 31.42, 32.08, 32.64, 39.19, 61.09, 127.04, 127.49, 130.77, 133.04, 140.64, 142.26, 160.42, 166.81. HiRes-MALDI: 365.24 $[M + Na]^+$.

Ethyl-3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl] Benzoate

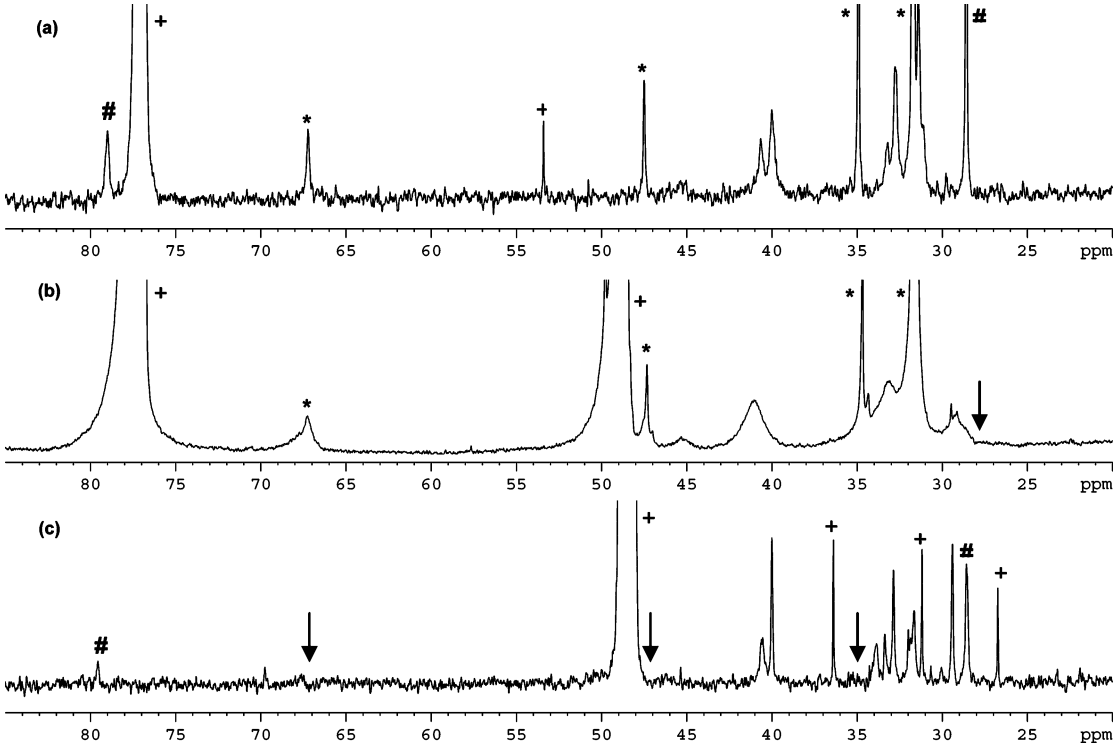


Figure 1. High field parts of the ^{13}C NMR spectra of polymer **13a** which carries 50% Fmoc* and 50% Boc protected peripheral amine groups (a) and its selectively deprotected counterparts **13b** carrying 50% Fmoc* and 50% unprotected amines (b) and **13c** carrying 50% Boc and 50% unprotected amine (c). The Fmoc* and Boc signals in the shift range given are marked by (∗) and (#), respectively. Solvents signals ($CDCl_3$, CD_3OD, DMF, CH_2Cl_2) are marked with the same symbol (+).

(2b). Compound **2a** (0.4 g, 1.1 mmol) and DIEA (0.36 mL, 2.2 mmol) in CH_2Cl_2/ MeOH (10 mL, v/v, 1/1) were added dropwise to a solution of (2,7-di-*tert*-butyl-9-fluorenyl)methyl 2,5-dioxopyrrolidin-1-yl carbonate (0.59 g, 1.32 mmol) in CH_2Cl_2 (20 mL) over 15 min at −30 °C. The resulting mixture was warmed to rt and stirred overnight. The product was washed with $NaHCO_3$ and brine. Chromatographic separation (silica gel, hexane/EtOAc: v/v: 2/1) yielded **2b** (0.68 g, 89%) as a slightly yellowish solid. ^1H NMR ($CDCl_3$): δ 1.27 (t, 3 H, CH_3), 1.36 (s, 18 H, CCH_3), 1.43 (s, 9 H, CCH_3), 1.84 (m, 4 H, CH_2), 2.65 (t, 4 H, CH_2Ph), 3.13 (q, 2 H, CH_2NH), 3.24 (q, 2 H, CH_2NH), 4.15 (t, 1 H, *CH*CH_2), 4.39 (m, 4 H, CH_2O), 4.59 (s, br, 1 H, NH), 4.93 (s, br, 1 H, NH), 7.19 (s, 1 H, ArH), 7.40 (d, 2 H, ArH), 7.58 (dd, 4 H, ArH), 7.69 (s, 2 H, ArH). ^{13}C NMR ($CDCl_3$): δ 14.41, 28.46, 31.65, 32.72, 32.80, 34.89, 40.03, 40.49, 47.33, 60.96, 67.03, 79.16, 119.22, 121.89, 124.72, 127.18, 127.27, 130.81, 133.19, 138.73, 141.82, 142.02, 144.8, 149.78, 156.04, 156.66, 166.79. HiRes-MALDI: 721.24 $[M + Na]^+$. Anal. Calcd for $C_{47}H_{60}N_4O_8$ (698.43): C 73.89, H 8.36, N 4.01. Found: C 73.61, H 8.11, N 3.96.

3-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)-propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoic Acid (2c). Compound **2a** (0.70 g, 1.90 mmol) was heated with KOH (0.43 g, 4 equiv) in THF/MeOH/H_2O (10/10/5, v/v) at 55 °C for 6 h. After the reaction was finished (TLC), water (3 mL) and then acetic acid were added until pH = 5 was reached. The solvent was evaporated. The resulting mixture and DIEA (0.8 mL, pH 8−9) in CH_2Cl_2/MeOH (25 mL, 3/2) were added dropwise into a solution of (2,7-di-*tert*-butyl-9-fluorenyl)methyl 2,5-dioxopyrrolidin-1-yl carbonate (1.10 g, 2.30 mmol) in CH_2Cl_2 (20 mL) over 15 min at −30 °C. The resulting mixture was warmed to rt and stirred overnight. The product was washed with $NaHCO_3$ and brine. Chromatographic separation (silica gel, hexane/EtOAc: v/v: 1/1) yielded **2c** (0.96 g, 75%) as a slightly yellow solid. ^1H NMR ($CDCl_3$): δ 1.28 (s, 18 H, CCH_3), 1.37 (s, 9 H, CCH_3), 1.70 (m, 4 H, CH_2), 2.54 (m, 4 H, CH_2Ph), 2.99 (q, 2 H, CH_2NH), 3.09 (q, 2 H, CH_2NH), 4.05 (t, 1 H, *CH*CH_2), 4.32 (q, 2 H, CH_2O), 7.09 (s, 1 H, ArH), 7.28 (d, 2 H, ArH), 7.50 (dd, 4 H, ArH), 7.59 (s, 2 H, ArH). ^{13}C NMR ($CDCl_3$): δ 28.46, 31.66, 31.77, 32.95, 34.90, 40.29, 46.73, 62.17, 67.17, 79.03, 119.20, 121.66, 124.69, 125.40, 126.80, 137.92, 138.80, 141.38, 141.63, 144.09, 144.26, 149.80, 156.12, 156.32, 169.55.

3-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)-propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoic Acid 2,5-Dioxopyrrolidin-1-yl Ester (2d). *N*-Hydroxysuccinimide (0.33 g, 2.87 mmol) was added into a solution of **2c** (1.55 g, 2.31 mmol) in dry CH_2Cl_2 (60 mL) at rt. After the mixture had been stirred for 15 min dicyclohexylcarbodiimide (0.65 g, 3.15 mmol) was added at −20 °C. The resulting mixture was warmed to rt and stirred overnight. After the precipitate had been filtered off, chromatographic separation (silica gel, hexane/EtOAc: v/v: 3/1) yielded **2d** (1.43 g, 81%) as a slightly yellowish solid. ^1H NMR ($CDCl_3$): δ 1.34 (s, 18 H, CCH_3), 1.42 (s, 9 H, CCH_3), 1.74 (m, 4 H, CH_2), 2.64 (t, 4 H, CH_2Ph), 2.89 (s, 4 H, CH_2), 3.11 (q, 2 H, CH_2NH), 3.21 (q, 2 H, CH_2NH), 4.11 (t, 1 H, *CH*CH_2), 4.39 (q, 2 H, CH_2O), 4.71 (s, br, 1 H, NH), 5.11 (s, br, 1 H, NH), 7.01 (s, 1 H, ArH), 7.39 (d, 2 H, ArH), 7.58 (dd, 4 H, ArH), 7.72 (s, 2 H, ArH). ^{13}C NMR ($CDCl_3$): δ 24.94, 25.69, 28.43, 31.44, 31.61, 32.55, 32.64, 33.86, 34.87, 39.89, 40.35, 47.30, 66.99, 70.19, 79.16, 119.18, 121.89, 124.70, 125.37, 128.05, 128.13, 135.40, 138.70, 142.59, 142.80, 144.05, 149.79, 156.05, 156.67, 169.39, 171.16. HiRes-MALDI: 790.40 $[M + Na]^+$. Anal. Calcd for $C_{45}H_{57}N_3O_8$ (767.21): C 70.38, H 7.48, N 5.47. Found: C 70.10, H 7.66, N 5.48.

Ethyl-3,5-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonyl-amino)propyl] Benzoate (3b). Compound **3a** (0.3 g, 0.90 mmol) and DIEA (0.44 mL, 2.50 mmol) in CH_2Cl_2/ MeOH (10 mL, v/v, 1/1) were added dropwise to a solution of (2,7-di-*tert*-butyl-9-fluorenyl)methyl 2,5-dioxopyrrolidin-1-yl carbonate (1.0 g, 2.22 mmol) in CH_2Cl_2 (20 mL) over 15 min at −30 °C. The resulting mixture was warmed to rt and stirred overnight. The product was washed with $NaHCO_3$ and brine. Chromatographic separation (silica gel, hexane/EtOAc: v/v: 2/1) yielded **2b** (0.6 g, 95%) as a slightly yellowish solid. ^1H NMR ($CDCl_3$): δ 1.26 (t, 3 H, CH_3), 1.37 (s, 36 H, CCH_3), 1.87 (m, 4 H, CH_2), 2.68 (t, 4 H, CH_2Ph), 3.24 (q, 4 H, CH_2NH), 4.20 (t, 2 H, *CH*CH_2), 4.45 (m, 6 H, CH_2O), 4.95 (s, br, 2 H, NH), 7.22 (s, 1 H, ArH), 7.39 (s, 2 H, ArH), 7.41 (s,

2 H, ArH), 7.64 (d, 8 H, ArH), 7.72 (s, 2 H, ArH). ^{13}C NMR ($CDCl_3$): δ 14.56, 31.79, 32.84, 35.05, 40.64, 47.46, 61.14, 67.17, 119.36, 122.02, 124.84, 127.40, 138.88, 141.94, 144.19, 149.92, 156.77. HiRes-MALDI: 956.32 $[M + Na]^+$. Anal. Calcd for $C_{61}H_{76}N_2O_6$ (933.27): C 78.50, H 8.21, N 3.00. Found: C 78.34, H 8.27, N 2.97.

3,5-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)-propyl]benzoic Acid (3c). Compound **3a** (0.35 g, 1.05 mmol) was heated with KOH (0.3 g, 5 equiv) in THF/MeOH/H_2O (10/10/5, v/v) at 55 °C for 6 h. After the reaction was finished (TLC), water (3 mL) and then acetic acid were added until pH = 5 was reached. The solvent was evaporated. The resulting mixture and DIEA (0.6 mL, pH 8−9) in CH_2Cl_2/MeOH (25 mL, 3/2) were added dropwise into a solution of (2,7-di-*tert*-butyl-9-fluorenyl)methyl 2,5-dioxo-pyrrolidin-1-yl carbonate (1.1 g, 2.3 mmol) in CH_2Cl_2 (20 mL) over 15 min at −30 °C. The resulting mixture was warmed to rt and stirred overnight. The product was washed with $NaHCO_3$ and brine. Chromatographic separation (silica gel, hexane/EtOAc: v/v: 2/1) yielded **3c** (0.90 g, 94%) as a slightly yellowish solid. ^{1}H NMR ($CDCl_3$): δ 1.35 (s, 36 H, CCH_3), 1.84 (m, 4 H, CH_2), 2.65 (t, 4 H, CH_2Ph), 3.20 (q, 4 H, CH_2NH), 4.16 (t, 2 H, *CH*CH_2), 4.41 (d, 4 H, CH_2O), 7.35 (s, 1 H, ArH), 7.38 (s, 2 H, ArH), 7.55−7.66 (m, 12 H, ArH. ^{13}C NMR ($CDCl_3$): δ 31.43, 32.54, 34.54, 37.87, 40.19, 47.21, 66.81, 119.09, 119.45, 121.71, 123.31, 124.62, 127.44, 127.70, 130.58, 133.32, 138.60, 141.83, 143.92, 149.79, 156.98, 169.05. HiRes-MALDI: 927.52 $[M + Na]^+$.

3-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)-propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzyl Alcohol (4). A solution of 2 M $LiBH_4$ (2.86 mL, 5.7 mmol) in dry THF (10) was added dropwise to a solution of **2b** (0.5 g, 0.72 mmol) in dry THF (15) at 0 °C. The reaction mixture was stirred overnight at rt and then quenched by adding dropwise 5% HCl (2 mL). The resulting precipitate was filtered off. Chromatographic separation (silica gel, hexane/EtOAc: v/v: 2/1) yielded **4** (0.43 g, 92%) as a slightly yellowish solid. ^{1}H NMR ($CDCl_3$): δ 1.39 (s, 18 H, CCH_3), 1.47 (s, 9 H, CCH_3),1.82 (m, 4 H, CH_2), 2.65 (t, 4 H, CH_2Ph), 3.14 (q, 2 H, CH_2NH), 3.24 (q, 2 H, CH_2NH), 4.20 (t, 1 H, *CH*CH_2), 4.55 (d, 2 H, CH_2O), 4.64 (s, 2 H, CH_2O), 4.95 (s, br, 2 H, NH), 6.92 (s, 1 H, ArH), 7.02 (s, 2 H, ArH), 7.43 (d, 2 H, ArH), 7.64 (dd, 4 H, ArH). ^{13}C NMR ($CDCl_3$): δ 28.46, 29.68, 29.87, 31.66, 31.77, 32.95, 34.90, 40.29, 46.73, 62.17, 67.17, 79.03, 119.20, 121.66, 124.69, 125.40, 126.80, 137.92, 138.80, 141.38, 141.63, 144.09, 144.26, 149.80, 156.12, 156.32. HiRes-MALDI: 679.41 $[M + Na]^+$. Anal. Calcd for $C_{41}H_{56}N_2O_5$ (656.42): C 74.97, H 8.59, N 4.26. Found: C 74.99, H 8.63, N 4.21.

3-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)-propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzyl Methacrylate (5). According to procedure A: MAC (0.11 mL) in CH_2Cl_2 (5 mL) was added to a solution of compound **4** (0.47 g, 0.71 mmol), DIEA (0.24 mL), and DMAP (10 mg) in CH_2Cl_2 (20 mL). Chromatographic separation (silica gel, hexane/EtOAc: v/v: 2/1) yielded **5** (0.49 g, 94%) as a slightly yellowish solid. ^{1}H NMR ($CDCl_3$): δ 1.41 (s, 18 H, CCH_3), 1.48 (s, 9 H, CCH_3),1.85 (m, 4 H, CH_2), 2.02 (s, 3 H, CH_3), 2.65 (t, 4 H, CH_2Ph), 3.16 (q, 2 H, CH_2NH), 3.28 (q, 2 H, CH_2NH), 4.22 (t, 1 H, *CH*CH_2), 4.56 (d, 2 H, CH_2O), 4.95 (s, br, 2 H, NH), 5.21 (s, 2 H, CH_2O), 5.61 (s, 1 H, CH_2=), 6.21 (s, 1 H, CH_2=), 7.02 (s, 1 H, ArH), 7.06 (s, 2 H, ArH), 7.43 (d, 2 H, ArH), 7.64 (dd, 4 H, ArH). ^{13}C NMR ($CDCl_3$): δ 18.25, 28.47, 31.66, 32.85, 32.92, 34.90, 40.14, 40.56, 47.34, 66.44, 67.02, 79.11, 119.24, 121.90, 124.73, 125.80, 125.88, 126.30, 128.44, 136.37, 136.37, 138.74, 141.92, 142.13, 144.09, 149.78, 156.06, 156.69, 167.28. HiRes-MALDI: 747.43 $[M + Na]^+$. Anal. Calcd for $C_{45}H_{60}N_2O_6$ (724.25): C 74.55, H 8.34, N 3.86. Found: C 74.29, H 8.31, N 3.83.

Poly{3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzyl Methacrylate} (6a). According to procedure B: monomer **5** (0.22 g) and DMF (70 μL) were used. Chromatographic separation yielded **6a** (0.14 g, 65%) as a slightly yellowish solid. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 0.83 (br, 3 H, CH_3), 1.31 (br, 27 H, CCH_3), 1.68 (br, 4 H, CH_2), 2.05 (br, 2 H, CH_2), 2.49 (br, 4 H, CH_2Ph), 3.00 (br, 2 H, CH_2NH), 3.10 (br, 2 H, CH_2NH), 4.05 (br, 1 H, *CH*CH_2), 4.25 (br, 2 H, CH_2O), 4.83 (br, 2 H, CH_2O), 5.19 (br, 1 H, NH), 5.74 (br, 1 H, NH), 6.87 (br, 3 H, ArH), 7.29 (br, 2 H, ArH), 7.52 (br, 4 H, ArH). ^{13}C NMR ($CDCl_3$, 500 MHz): δ 28.64, 31.30, 31.73, 32.97, 34.90, 40.35, 40.77, 47.52, 67.20, 78.90, 119.27, 121.95, 124.71, 125.95, 135.57, 138.80, 142.08, 142.33, 144.30, 149.84, 156.18, 156.81.

Poly{3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]-5-[3-(amino)propyl]benzyl Methacrylate x HCl} (6b). 25% HCl (0.28 mL), THF (10 mL), and **6a** (90 mg) were used. Evaporation of the solvent yielded **6b** (82 mg, 96%) as a slightly greenish solid. ^{1}H NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 0.83 (br, 3 H, CH_3), 1.28 (br, 18 H, CCH_3), 1.70 (br, 2 H, CH_2), 1.98 (br, 4 H, CH_2), 2.48 (br, 4 H, CH_2Ph), 2.89 (br, 2 H, CH_2NH), 3.04 (br, 2 H, CH_2NH), 4.05 (br, 1 H, *CH*CH_2), 4.25 (br, 2 H, CH_2O), 4.83 (br, 2 H, CH_2O), 6.94 (br, 3 H, ArH), 7.26 (br, 2 H, ArH), 7.48 (br, 4 H, ArH). ^{13}C NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 28.81, 31.35, 32.44, 32.87, 34.68, 39.57, 40.70, 45.36, 57.34, 67.12, 119.21, 121.73, 124.65, 126.02, 128.48, 135.53, 138.70, 141.07, 142.53, 144.10, 149.87, 157.48.

Poly{3-[3-(amino)propyl]-5-[3-(*tert*-butyloxycarbonylamino)-propyl]benzyl Methacrylate x HCl} (6c). 25% piperidene (1.2 mL), DMF (10 mL), and **6a** (0.1 g) were used to yield **6c** (50 mg, 80%) as a colorless solid. ^{1}H NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 0.85 (br, 3 H, CH_3), 1.43 (br, 9 H, CCH_3), 1.77 (br, 2 H, CH_2), 2.05 (br, 2 H, CH_2), 2.59 (br, 2 H, CH_2Ph), 2.70 (br, 2 H, CH_2Ph), 2.99 (br, 2 H, CH_2NH), 3.06 (br, 2 H, CH_2NH), 4.92 (br, 2 H, CH_2O), 7.09 (br, 3 H, ArH). ^{13}C NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 28.73, 30.98, 32.64, 39.19, 39.87, 66.77, 78.66, 126.00, 128.32, 135.54, 141.03, 141.32, 142.65, 157.01.

3,5-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)-propyl]benzyl Alcohol (7). A solution of 2 M $LiBH_4$ (3.2 mL, 4.8 mmol) in dry THF (10 mL) was added dropwise to a solution of **3b** (0.45 g, 0.48 mmol) in dry THF (15 mL) at 0 °C. The reaction mixture was stirred overnight at rt and then quenched by adding dropwise 5% HCl (2 mL). The resulting precipitate was filtered off. Chromatographic separation (silica gel, hexane/EtOAc: v/v: 2/1) yielded **7** (0.37 g, 87%) as a greenish solid. ^{1}H NMR ($CDCl_3$): δ 1.39 (s, 36 H, CCH_3), 1.87 (m, 4 H, CH_2), 2.66 (t, 4 H, CH_2Ph), 3.24 (q, 4 H, CH_2NH), 4.20 (t, 2 H, $CHCH_2$), 4.43 (d, 4 H, CH_2O), 4.67 (s, 2 H, CH_2O), 4.95 (s, br, 2 H, NH), 6.97 (s, 1 H, ArH), 7.05 (s, 2 H, ArH), 7.42 (s, 2 H, ArH), 7.44 (s, 2 H, ArH), 7.66 (d, 8 H, ArH). ^{13}C NMR ($CDCl_3$): δ 31.80, 32.95, 35.05, 40.64, 47.46, 65.37, 67.17, 119.37, 122.02, 124.84, 138.88, 141.94, 144.20, 149.93, 156.79. HiRes-MALDI: 914.34 $[M + Na]^+$. Anal. Calcd for $C_{59}H_{74}N_2O_5$ (891.23): C 73.89, H 8.36, N 4.01. Found: C 73.61, H 8.11, N 3.96.

3,5-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)-propyl]benzyl Methacrylate (8). According to procedure A: MAC (0.05 mL) in CH_2Cl_2 (5 mL) was added to a solution of compound **7** (0.26 g, 0.29 mmol), DIEA (0.05 mL) and DMAP (8 mg) in CH_2Cl_2 (15 mL). Chromatographic separation (silica gel, hexane/EtOAc: v/v: 3/1) yielded **8** (0.22 g, 78%) as a greenish solid. ^{1}H NMR ($CDCl_3$): δ 1.41 (s, 36 H, CCH_3), 1.90 (m, 4 H, CH_2), 2.02 (s, 3 H, CH_3), 2.68 (t, 4 H, CH_2Ph), 3.28 (q, 4 H, CH_2NH), 4.20 (t, 2 H, *CH*CH_2), 4.45 (d, 4 H, CH_2O), 5.08 (s, br, 2 H, NH), 5.20 (s, 2 H, CH_2O), 5.62 (s, 1 H, CH_2=), 6.21 (s, 1 H, CH_2=), 7.03 (s, 1 H, ArH), 7.08 (s, 2 H, ArH), 7.43 (s, 2 H, ArH), 7.46 (s, 2 H, ArH), 7.66 (d, 8 H, ArH). ^{13}C NMR ($CDCl_3$): δ 18.43, 26.96, 31.66, 31.87, 32.82, 34.90, 40.57, 47.34, 66.43, 67.04, 119.24, 121.89, 124.73, 125.76, 125.89, 128.43, 136.26, 136.44, 138.75, 141.94, 144.08, 149.77, 156.65, 167.28, 175.69. HiRes-MALDI: 982.46 $[M + Na]^+$. Anal. Calcd for $C_{63}H_{78}N_2O_6$ (959.30): C 78.88, H 8.20, N 2.92. Found: C 78.63, H 8.20, N 2.92.

Poly{3,5-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl] benzyl methacrylate} (9a). According to procedure B: monomer **8** (0.27 g) and DMF (75 μL) were used. Polymerization at 70 °C for 18 h. Chromatographic separation yielded **9a** (0.17 g, 63%) as a greenish solid. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 0.94 (br, 3 H, CH_3), 1.29 (br, 36 H, CCH_3), 1.74 (br, 4 H, CH_2), 2.52 (br, 4 H, CH_2Ph), 3.11 (br, 4 H, CH_2NH), 4.00 (br, 2 H,

CHCH_2), 4.25 (br, 4 H, CH_2O), 4.92 (br, 2 H, CH_2O), 5.63 (br, 2 H, NH), 6.91 (br, 3 H, ArH), 7.29 (br, 4 H, ArH), 7.52 (br, 8 H, ArH). ^{13}C NMR ($CDCl_3$, 500 MHz): δ 30.82, 31.63, 32.72, 34.75, 40.52, 47.17, 67.02, 119.19, 121.84, 124.60, 125.89, 128.31, 135.61, 138.61, 141.95, 144.03, 144.03, 149.56, 156.74.

Poly{3,5-[3-(amino)propyl]benzyl Methacrylate x 2HCl} (9b). According to procedure D: 25% aqueous piperidene (3.5 mL), DMF (15 mL), and **9a** (0.15 g) were used to yield **9b** (50 mg, 85%) as a viscous oil. ^{1}H NMR (CD_3OD, 500 MHz): δ 0.85 (br, CH_3), 1.85 (br, CH_2), 2.55 (br, $ArCH_2$), 3.11 (br, $NHCH_2$), 4.85 (br, CH_2-CH_3), 6.94 (br, ArH). ^{13}C NMR (CD_3OD, 500 MHz): δ 31.56, 32.87, 40.20, 125.86, 127.61, 139.18, 141.38, 168.24.

3,5-Bis(3-{3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoylamino}propyl)benzyl Alcohol (11). Compound **10** (0.2 g, 0.67 mmol) and DIEA (0.4 mL, 2.4 mmol) in MeOH (10 mL) was added dropwise to a solution of **2d** (1.3 g, 1.7 mmol) in CH_2Cl_2 (25 mL) at −30 °C over 10 min. The resulting mixture was warmed to rt and stirred for 20 h. The product was washed with $NaHCO_3$ and brine. Chromatographic separation (silica gel, hexane/EtOAc: v/v: 3/1) yielded **11** (0.89 g, 86%) as a slightly yellowish solid. ^{1}H NMR ($CDCl_3$): δ 1.41 (s, 36 H, CCH_3), 1.48 (s, 18 H, CCH_3),1.84 (m, 8 H, CH_2), 1.92 (m, 4 H, CH_2), 2.64 (m, 12 H, CH_2Ph), 3.08 (q, 4 H, CH_2NH), 3.20 (q, 4 H, CH_2NH), 3.46 (q, 4 H, CH_2NH), 4.16 (t, 2 H, *CH*CH_2), 4.40 (d, 4 H, CH_2O), 4.58 (s, 2 H, CH_2O), 4.85 (s, br, 2 H, NH), 5.31 (s, br, 2 H, NH), 6.94 (s, 1 H, ArH), 7.01 (s, 3 H, ArH), 7.09 (s, 3 H, ArH), 7.40 (d 2 H, ArH), 7.43 (d, 2 H, ArH), 7.60 (dd, 8 H, ArH), 7.65 (s, 2 H, ArH). ^{13}C NMR ($CDCl_3$): δ 28.44, 30.80, 31.36, 31.62, 32.44, 33.26, 34.87, 39.63, 40.25, 47.28, 64.92, 67.04, 79.19, 119.20, 121.86, 124.73, 127.61, 131.57, 134.92, 138.69, 141.57, 141.75, 141.87, 144.03, 149.79, 156.19, 156.77, 167.83. HiRes-MALDI: 1551.28 $[M + Na]^+$. Anal. Calcd for $C_{95}H_{126}N_6O_{11}$ (1528.05): C 74.67, H 8.31 N, 5.50. Found: C 74.39, H 8.30, N 5.38.

3,5-Bis(3-{3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoylamino}propyl)benzyl Methaacrylate (12). According to procedure A: MAC (0.08 mL) in CH_2Cl_2 (5 mL) was added to **11** (0.84 g, 0.55 mmol), DIEA (0.22 mL), and DMAP (20 mg) in CH_2-Cl_2 (25 mL). Chromatographic separation (silica gel, hexane/EtOAc: v/v: 2/1) yielded **12** (0.67 g, 77%) as a slightly greenish solid. ^{1}H NMR ($CDCl_3$): δ 1.41 (s, 36 H, CCH_3), 1.48 (s, 18 H, CCH_3),1.87 (m, 12 H, CH_2), 2.02 (s, 3 H, CH_3), 2.65 (m, 12 H, CH_2Ph), 3.10 (q, 4 H, CH_2NH), 3.22 (q, 4 H, CH_2NH), 3.46 (q, 4 H, CH_2NH), 4.16 (t, 2 H, *CH*CH_2), 4.38 (d, 4 H, CH_2O), 4.95 (s, br, 1 H, NH), 5.10 (s, 2 H, CH_2O), 5.31 (s, br, 1 H, NH), 5.58 (s, 1 H, CH_2=), 6.14 (s, 1 H, CH_2=), 7.03 (s, 4 H, ArH), 7.10 (s, 3 H, ArH), 7.39 (d, 2 H, ArH), 7.43 (d, 2 H, ArH), 7.47 (s, 2 H, ArH), 7.64 (dd, 8 H, ArH). ^{13}C NMR ($CDCl_3$): δ 18.29, 28.44, 30.94, 31.28, 31.66, 32.32, 32.49, 33.12, 34.86, 39.51, 39.61, 40.20, 47.28, 66.42, 67.06, 79.12, 119.22, 121.86, 124.73, 124.89, 125.89, 126.05, 128.48, 129.01, 131.59, 134.94, 136.18, 136.29, 138.70, 141.75, 142.06, 144.03, 149.78, 156.20, 156.78, 167.29, 167.91, 169.91. HiRes-MALDI: 1617.96 $[M + Na]^+$. Anal. Calcd for $C_{99}H_{130}N_6O_{12}$ (1594.97): C 74.50, H 8.21, N 5.27. Found: C 74.24, H 8.26, N 5.15.

Poly{3,5-bis(3-{3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoylamino}propyl)benzyl Methaacrylate} (13a). According to procedure B: monomer **12** (0.3 g) and DMF (80 μL) were used. Polymerization at 70 °C for 22 h. Chromatographic separation yielded **13a** (0.25 g, 83%) as a slightly yellowish solid. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.30 (br, 54 H, CCH_3), 1.67 (br, 8 H, CH_2), 1.87 (br, 6 H, CH_2), 2.45 (br, 12 H, CH_2Ph), 2.91 (br, 4 H, CH_2-NH), 3.05 (br, 4 H, CH_2NH), 3.65 (br, 4 H, CH_2NH), 4.06 (br, 2 H, *CH*CH_2), 4.28 (br, 4 H, CH_2O), 4.85 (br, 2 H, CH_2O), 6.88−6.99 (br, 5 H, ArH), 7.29−7.61 (br, 16 H, ArH). ^{13}C NMR ($CDCl_3$, 500 MHz): δ 28.59, 31.40, 31.60, 31.72, 32.79, 33.19, 34.90, 40.01, 40.66, 47.49, 50.77, 53.40, 67.23, 78.98, 119.27, 11.37, 121.54, 121.95, 124.75, 124.98, 131.47, 135.10, 138.77, 141.97, 144.26, 149.88, 156.27, 156.86, 168.09.

Poly{3,5-bis(3-{3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]-5-[3-(amino)propyl]benzoylamino}propyl)benzyl Methaacrylate *x* 2HCl} (13b). According to procedure C: 25% HCl (0.1 mL), THF (8 mL), and **13a** (60 mg) were used. Evaporation of the solvent yielded **13b** (52 mg, 94%) as a yellowish solid. ^{1}H NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 0.85 (br, 3 H, CH_3), 1.22 (br, 36 H, CCH_3), 1.65 (br, 8 H, CH_2), 1.85 (br, 4 H, CH_2), 2.49 (br, 12 H, CH_2Ph), 2.97 (br, 8 H, CH_2NH), 3.29 (br, 4 H, CH_2NH), 3.99 (br, 4 H, *CH*CH_2), 4.37 (br, 2 H, CH_2O), 6.95−7.64 (br, 21 H, ArH). ^{13}C NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 29.47, 31.40, 31.68, 34.68, 41.05, 47.33, 67.23, 119.13, 121.81, 121.54, 122.85, 124.61, 126.07, 127.83, 132.28, 134.90, 135.30, 137.22, 138.53, 140.65, 142.31, 143.90, 149.82, 157.18, 168.65.

Poly{3,5-bis(3-{3-[3-(amino)propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoylamino}propyl)benzyl Methaacrylate x 2HCl} (13c). According to procedure D: 25% aqueous piperidene (0.8 mL), DMF (8 mL) and **13a** (70 mg) were used to yield **13c** (40 mg, 91%) as a colorless solid. ^{1}H NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 0.85 (br, 3 H, CH_3), 1.34 (br, 18 H, CCH_3), 1.67 (br, 4 H, CH_2), 1.85 (br, 4 H, CH_2), 1.98 (br, 4 H, CH_2), 2.52 (br, 12 H, CH_2Ph), 2.98 (br, 4 H, CH_2NH), 3.12 (br, 4 H, CH_2-NH), 3.30 (br, 4 H, CH_2NH), 4.79 (br, 2 H, CH_2O), 6.90 (br, 2 H, ArH), 6.90 (br, 2 H, ArH), 7.44 (br, 5 H, ArH). ^{13}C NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 29.08, 29.89, 32.14, 32.49, 33.36, 33.88, 34.36, 34.77, 40.50, 41.04, 47.33, 79.80, 126.14, 126.52, 127.46, 132.83, 136.20, 136.36, 142.39, 142.70, 143.60, 144.29, 156.13, 158.40, 164.86.

3-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]-5-[3-(amino)propyl]benzyl Alcohol (14). To a solution of compound **4** (0.60 g, 0.91 mmol) in THF (25 mL) was slowly added a solution of 25% HCl (0.55 mL, 4 equiv) in THF (3 mL) under N_2 at 0 °C. The reaction was stirred for 3 h and controlled with TLC. The solvent was evaporated at rt to yield **14** as viscous oil (0.50 g, 94%). The product was used for next step without further purification procedures.

3-{3,5-Bis-[3-(*tert*-butyloxycarbonylamino)propyl]benzoylamino}-5-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]benzyl Alcohol (15a). To a solution of the acid dendron **1b** (0.48 g, 1.02 mmol) in CH_2Cl_2 (25 mL) were added *N*-hydroxybenzotriazol (0.15 g, 1.10 mmol) at rt. After 10 min at −30 °C, *N*-(3-(dimethylamino)propyl)-*N*′-ethylcarbodiimide hydrochloride (0.22 g, 1.15 mmol) was added. The mixture was stirred for 3 h. Then a solution of **14** (0.50 g, 0.85 mmol) and DIEA (0.3 mL, 1.68 mmol) in a mixed solvent of methanol/CH_2Cl_2 (15 mL, 1/1) was added dropwise at −20 °C. The resulting mixture was warmed to rt and stirred for 14 h. It was then washed with brine and aqueous $NaHCO_3$. The organic phase was dried over $MgSO_4$, and the solvent was removed in vacuum. Chromatographic separation (silica gel, AcOEt/hexane, v/v, 1/1) yielded **15a** (0.67, 82%) as a slightly yellowish solid. ^{1}H NMR ($CDCl_3$): δ 1.36 (s, 18 H, CCH_3), 1.44 (s, 18 H, CCH_3), 1.77 (m, 2 H, CH_2), 1.86 (m, 4 H, CH_2), 1.96 (m, 2 H, CH_2), 2.58 (t, 2 H, CH_2Ph), 2.70 (m, 6 H, CH_2Ph), 3.10 (q, 2 H, CH_2NH), 3.22 (q, 4 H, CH_2NH), 3.42 (q, 2 H, CH_2NH), 4.16 (t, 1 H, *CH*CH_2), 4.40 (d, 2 H, CH_2O), 4.59 (s, 2 H, CH_2O), 5.09 (s, br, 1 H, NH), 6.96 (s, 1 H, ArH), 7.00 (s, 2 H, ArH), 7.16 (s, 1 H, ArH), 7.38 (s 2 H, ArH), 7.43 (d, 2 H, ArH), 7.60 (dd, 4 H, ArH).^{13}C NMR ($CDCl_3$): δ 28.34, 30.81, 31.56, 31.59, 32.48, 32.90, 33.48, 34.88, 39.80, 40.15, 47.28, 65.18, 67.05, 79.15, 119.24, 121.90, 124.71, 127.61, 134.90, 138.73, 141.57, 141.78, 142.14, 144.07, 149.81, 156.11, 156.68, 168.73. HiRes-MALDI: 997.22 $[M + Na]^+$. Anal. Calcd for $C_{59}H_{82}N_4O_8$ (974.61): C 72.66, H 8.47, N 5.74. Found: C 72.45, H 8.55, N 5.68.

3-{3,5-Bis[3-(*tert*-butyloxycarbonylamino)propyl]benzoylamino}-5-[3-(amino)propyl]benzyl Alcohol (15b). 20% aqueous piperidene (7 mL, 20 equiv) was added dropwise to a solution of **15a** (0.67 g, 0.69 mmol) in DMF (25 mL). The mixture was stirred for 14 h, and the reaction was controlled with TLC. The mixture was washed three times with hexane. The solvent was evaporated to yield **15b** (0.42 g, 95%) as a slightly brown oil. The product was used for next step without further purification.

3-(3-{3-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoyl}amino)propyl-5-(3-{3,5-bis-[3-(*tert*-butyloxycarbonylamino)propyl]benzoyl}-amino)propylbenzyl Alcohol (16). Compound **15b** (0.73 g, 1.14 mmol) and DIEA (0.3 mL, 1.9 mmol) in CH_2Cl_2/MeOH (15 mL, 2/1) were added dropwise to a solution of **2d** (1.0 g, 1.3 mmol) in CH_2Cl_2 (25 mL) at −30 °C over 10 min. The resulting mixture was warmed to rt and stirred for 20 h. The product was washed with $NaHCO_3$ and brine. Chromatographic separation (silica gel, hexane/EtOAc: v/v: 1/2) yielded **16** (1.28 g, 87%) as a slightly yellowish solid. δ 1.40 (s, 18 H, CCH_3), 1.47 (s, 27 H, CCH_3), 1.87 (m, 8 H, CH_2), 1.94 (m, 4 H, CH2), 2.67 (m, 12 H, CH_2Ph), 3.06 (q, 6 H, CH_2NH), 3.19 (q, 2 H, CH_2NH), 3.44 (q, 4 H, CH_2-NH), 4.15 (t, 1 H, *CH*CH_2), 4.38 (d, 4 H, CH_2O), 4.59 (s, 2 H, CH_2O), 4.85 (s, br, 3 H, NH), 6.95 (s, 3 H, ArH), 7.04 (s, 2 H, ArH), 7.09 (s, 2 H, ArH), 7.37 (m, 4 H, ArH), 7.59 (m, 4 H, ArH). ^{13}C NMR ($CDCl_3$): δ 18.57, 30.98, 31.49, 31.72, 32.73, 33.44, 34.95, 39.81, 47.57, 65.00, 79.24, 119.29, 121.92, 124.79, 124.92, 127.65, 131.54, 138.85, 142.06, 142.09, 144.25, 150.29, 156.20, 156.78, 167.27. HiRes-MALDI: 1315.79 $[M + Na]^+$. Anal. Calcd for $C_{77}H108N_6O_{11}$ (1292.81): C 71.49, H 8.41, N 6.50. Found: C 71.20, H 8.48, N 6.41.

3-(3-{3-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoyl}amino)propyl-5-(3-{3,5-bis-[3-(*tert*-butyloxycarbonylamino)propyl]benzoyl}-amino)propylbenzyl Methacrylate (17). According to procedure A: MAC (0.05 mL) in CH_2Cl_2 (5 mL) was added to a solution of compound **16** (0.43 g, 0.33 mmol), DIEA (0.11 mL), and DMAP (10 mg) in CH_2Cl_2 (15 mL). Chromatographic separation (silica gel, hexane/EtOAc: v/v: 1/2) yielded **17** (0.43 g, 95%) as a slightly yellow solid. ^{1}H NMR ($CDCl_3$): δ 1.41 (s, 18 H, CCH_3), 1.48 (s, 27 H, CCH_3), 1.87 (m, 12 H, CH_2), 2.02 (s, 3 H, CH_3), 2.65 (m, 12 H, CH_2Ph), 3.06 (q, 6 H, CH_2NH), 3.18 (q, 2 H, CH_2NH), 3.46 (q, 4 H, CH_2NH), 4.16 (t, 1 H, *CH*CH_2), 4.38 (d, 4 H, CH_2O), 4.95 (s, br, 2 H, NH), 5.08 (s, 2 H, CH_2O), 5.37 (s, br, 1 H, NH), 5.57 (s, 1 H, CH_2=), 6.12 (s, 1 H, CH_2=), 7.01 (s, 3 H, ArH), 7.07 (s, 1 H, ArH), 7.09 (s, 1 H, ArH), 7.14 (s, br, 2 H, NH) 7.39 (d, 2 H, ArH), 7.40 (s, 4 H, ArH), 7.64 (dd, 4 H, ArH). ^{13}C NMR ($CDCl_3$): δ 18.29, 28.42, 30.98, 31.32, 31.60, 32.42, 33.13, 34.84, 39.61, 40.22, 47.27, 66.41, 67.03, 79.05, 119.19, 121.85, 124.71, 124.89, 125.87, 125.96, 128.45, 128.59, 131.57, 134.85, 135.07, 136.16, 136.26, 136.48, 138.67, 141.77, 142.06, 142.09, 144.02, 149.77, 156.20, 156.78, 167.27, 167.92. HiRes-MALDI: 1383.80 $[M + Na]^+$. Anal. Calcd for $C_{81}H_{192}N_6O_{12}$ (1360.83): C 71.44, H 8.29, N 6.17. Found: C 71.34, H 8.37, N 6.03.

Poly{3-(3-{3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoyl}-amino)propyl-5-(3-{3,5-bis-[3-(*tert*-butyloxycarbonylamino)-propyl]benzoyl}amino)propylbenzyl Methacrylate} (18a). According to procedure B: Monomer **17** (0.32 g) and DMF (60 μL) were used. It was polymerized at 70 °C for 20 h. Chromatographic separation yielded **18a** (0.24 g, 75%) as a slightly yellowish solid. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 1.32 (br, 45 H, CCH_3), 1.62 (br, 8 H, CH_2), 1.86 (br, 4 H, CH_2), 2.44 (br, 12 H, CH_2Ph), 2.95 (br, 6 H, CH_2NH), 3.07 (br, 2 H, CH_2NH), 3.36 (br, 4 H, CH_2NH), 4.07 (br, 1 H, *CH*CH_2), 4.30 (br, 2 H, CH_2O), 5.11 (br, 4 H, NH), 7.00 (br, 5 H, ArH), 7.32 (br, 3 H, ArH), 7.45 (br, 2 H, ArH), 7.54 (br, 8 H, ArH). ^{13}C NMR ($CDCl_3$, 500 MHz): δ 18.29, 28.60, 29.77, 31.39, 31.72, 32.77, 34.91, 40.12, 47.54, 66.42, 78.91, 119.25, 121.97, 124.73, 125.16, 135.15, 138.79, 142.01, 144.30, 149.91, 156.31, 156.88, 168.08.

Poly{3-(3-{3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino]-5-[3-(amino)propyl]benzoyl}amino)propyl-5-(3-{3,5-bis[3-(amino)propyl]benzoyl}amino)propylbenzyl Methacrylate *x* 3HCl} (18b). According to procedure C: 25% HCl (0.8 mL), THF (10 mL), and **18a** (0.1 g) were used. Evaporation of the solvent yielded **18b** (80 mg, 92%) as a slightly yellowish solid. ^{1}H NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 0.78 (br, 3 H, CH_3), 1.25 (br, 18 H, CCH_3), 1.79 (br, 2 H, CH_2), 1.87 (br, 4 H, CH_2), 1.98 (br, 6 H, CH_2), 2.58 (br, 12 H, CH_2Ph), 2.87 (br, 8 H, CH_2NH), 3.04 (br, 2 H, CH_2NH), 3.29 (br, 4 H, CH_2NH), 4.05 (br, 1 H, *CH*CH_2), 4.26 (br, 2 H, CH_2O), 6.91 (br, 3 H, ArH), 7.12 (br, 1 H, ArH), 7.19 (br, 1 H, ArH), 7.28 (br, 2 H, ArH), 7.52 (br, 8 H, ArH). ^{13}C NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 28.49, 30.84, 31.27, 32.14, 34.66, 39.27, 40.01, 47.33, 67.05, 119.18, 121.72, 124.65, 125.38, 131.68, 134.84, 138.71, 141.27, 142.30, 142.59, 144.11, 149.96, 157.58, 168.65.

Poly{3-(3-{3-[3-(amino]-5-[3-(*tert*-butyloxycarbonylamino)-propyl]benzoyl}amino)propyl-5-(3-{3,5-bis[3-(*tert*-butyloxycarbonylamino)propyl]benzoyl}amino)propylbenzyl Methacrylate x HCl} (18c). According to procedure D: 25% aqueous piperidene (1.5 mL), DMF (20 mL), and **18a** (0.12 g) were used to yield **18c** (75 mg, 82%) as a colorless solid. ^{1}H NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 0.82 (br, 3 H, CH_3), 1.32 (br, 27 H, CCH_3), 1.64 (br, 6 H, CH_2), 1.79 (br, 4 H, CH_2), 1.96 (br, 2 H, CH_2), 2.48 (br, 12 H, CH_2Ph), 2.95 (br, 4 H, CH_2NH), 3.12 (br, 2 H, CH_2-NH), 3.30 (br, 4 H, CH_2NH), 4.79 (br, 2 H, CH_2O), 7.03 (br, 4 H, ArH), 7.43 (br, 5 H, ArH). ^{13}C NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 28.37, 31.44, 32.72, 40.00, 79.02, 125.18, 142.25, 142.70, 156.88, 168.76.

3-[3-(Amino)propyl]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzyl Alcohol (19). 20% aqueous piperidene (9 mL, 18.3 mmol) was added dropwise to a solution of compound **4** (0.40 g, 0.61 mmol) in DMF (20 mL). The mixture was stirred for 14 h, and the reaction was controlled with TLC. It was washed two times with hexane. The solvent was evaporated to yield **19** (0.20 g, 94%) as a slightly brown oil. The product was used for next step without further purification.

3-{3,5-Bis[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonyl-amino)propyl]benzoylamino}-5-[3-(tert-butyloxycarbonylamino)propyl]benzyl Alcohol (20a). To a solution of the acid dendron **3c** (1.21 g, 1.34 mmol) in CH_2Cl_2 (30 mL) were added *N*-hydroxybenzotriazol (0.19 g, 1.40 mmol) at rt. After 10 min at −30 °C *N*-(3-(dimethylamino)propyl)-*N*′-ethylcarbodiimide hydrochloride (0.28 g, 1.56 mmol) was added. The mixture was stirred for 3 h. Then a solution of **19** (0.20 g, 0.56 mmol) and DIEA (0.3 mL, 1.68 mmol) in a mixed solvents of methanol/CH_2Cl_2 (15 mL, 1/1) were added dropwise at −20 °C. The resulting mixture was warmed up to rt and stirred for 14 h. It was then washed with brine and aqueous $NaHCO_3$. The organic phase was dried over $MgSO_4$, and the solvent was removed in vacuum. Chromatographic separation (silica gel, AcOEt/hexane, v/v, 1/1) yielded **20a** (0.55, 83%) as a slightly greenish solid. ^{1}H NMR ($CDCl_3$): δ 1.37 (s, 36 H, CCH_3), 1.41 (s, 9 H, CCH_3), 1.78 (m, 2 H, CH_2), 1.84 (m, 4 H, CH_2), 1.96 (m, 2 H, CH_2), 2.58 (t, 2 H, CH_2Ph), 2.68 (m, 6 H, CH_2Ph), 3.08 (q, 2 H, CH_2NH), 3.22 (q, 4 H, CH_2NH), 3.46 (q, 2 H, CH_2NH), 4.16 (t, 2 H, *CH*CH_2), 4.42 (d, 4 H, CH_2O), 4.59 (s, 2 H, CH_2O), 5.09 (s, br, 1 H, NH), 6.94 (s, 1 H, ArH), 7.00 (s, 2 H, ArH), 7.13 (s, 1 H, ArH), 7.38 (s 2 H, ArH), 7.43 (d, 4 H, ArH), 7.60 (dd, 8 H, ArH).^{13}C NMR ($CDCl_3$): δ 28.44, 30.80, 31.33, 31.62, 32.44, 32.90, 33.48, 34.88, 39.77, 40.15, 47.28, 65.15, 67.05, 79.19, 119.20, 121.86, 124.73, 127.61, 134.92, 138.69, 141.57, 141.75, 142.04, 144.03, 149.79, 156.01, 156.73, 168.83. HiRes-MALDI: 1232.75 $[M + Na]^+$. Anal. Calcd for $C_{77}H_{100}N_4O_8$ (1209.65): C 76.45, H 8.33, N 4.73. Found: C 76.15, H 8.37, N 4.36.

3-{3,5-Bis[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonyl-amino)propyl]benzoylamino}-5-[3-(amino)propyl]benzyl Alcohol (20b). To a solution of **20a** (0.60 g, 0.50 mmol) in THF (25 mL) was slowly added a solution of 25% HCl (0.65 mL, 4 equiv) in THF (3 mL) under nitrogen at 0 °C. The reaction was stirred for 3 h and controlled with TLC. The solvent was evaporated at rt to yield **20b** as a slightly greenish oil (0.57 g, 98%). The product was used for next step without further purification procedures.

3-(3-{3-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoyl}amino)propyl-5-(3-{3,5-bis[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonyl-amino)propyl]benzoyl}amino)propylbenzyl Alcohol (21). Compound **20b** (0.55 g, 0.49 mmol) and DIEA (0.12 mL, 0.75 mmol) in MeOH/CH_2Cl_2 (15 mL, 1/1) were added dropwise to a solution of **2d** (0.46 g, 0.59 mmol) in CH_2Cl_2 (20 mL) at −30 °C over 10 min. The resulting mixture was warmed to rt and stirred for 20 h. The product was washed with $NaHCO_3$ and brine. Chromatographic

separation (silica gel, hexane/EtOAc: v/v: 1/2) yielded **21** (0.80 g, 90%) as a slightly greenish solid. ^{1}H NMR ($CDCl_3$): δ 1.35 (s, 54 H, CCH_3), 1.42 (s, 9 H, CCH_3), 1.76 (m, 8 H, CH_2), 1.93 (m, 4 H, CH_2), 2.62 (m, 12 H, CH_2Ph), 3.07 (q, 2 H, CH_2NH), 3.18 (q, 6 H, CH_2NH), 3.41 (q, 4 H, CH_2NH), 4.16 (t, 3 H, *CH*CH_2), 4.37 (d, 6 H, CH_2O), 4.55 (s, 2 H, CH_2O), 5.10 (s, br, 3 H, NH), 6.94 (s, 1 H, ArH), 6.98 (s, 2 H, ArH), 7.13 (s, 2 H, ArH), 7.38 (d, 9 H, ArH), 7.60 (dd, 12 H, ArH). ^{13}C NMR ($CDCl_3$): δ 28.44, 30.80, 31.33, 31.62, 32.44, 32.90, 33.48, 34.88, 39.77, 40.15, 47.28, 64.87, 67.05, 79.09, 119.20, 119.66, 121.86, 122.10, 124.68, 124.82, 127.54, 131.43, 135.15, 138.72, 141.67, 141.75, 144.09, 149.82, 156.15, 156.74, 167.78. HiRes-MALDI: 1785.08 $[M + Na]^+$. Anal. Calcd for $C_{113}H_{144}N_6O_{11}$ (1762.41): C 77.01, H 8.24, N 4.77. Found: C 76.24, H 8.25, N 4.59.

3-(3-{3-[3-(2,7-Di-*tert*-butyl-9-fluorenylmethoxycarbonylamino]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoyl}amino)propyl-5-(3-{3,5-bis-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]benzoyl}amino)propylbenzyl Methacrylate (22). According to procedure A: MAC (0.05 mL) in CH_2Cl_2 (5 mL) was added to a solution of compound **16** (0.55 g, 0.30 mmol), DIEA (0.08 mL), and DMAP (10 mg) in CH_2Cl_2 (15 mL). Chromatographic separation (silica gel, hexane/EtOAc: v/v: 1/2) yielded **22** (0.50 g, 87%) as a slightly greenish solid. ^{1}H NMR ($CDCl_3$): δ 1.36 (s, 54 H, CCH_3), 1.41 (s, 9 H, CCH_3), 1.76 (m, 8 H, CH_2), 1.93 (m, 4 H, CH_2), 1.98 (s, 3 H, CH_3), 2.58 (m, 12 H, CH_2Ph), 3.01 (q, 2 H, CH_2NH), 3.14 (q, 6 H, CH_2NH), 3.41 (q, 4 H, CH_2-NH), 4.16 (t, 3 H, *CH*CH_2), 4.37 (d, 6 H, CH_2O), 4.84 (s, br, 1 H, NH), 5.01 (s, 2 H, CH_2O), 5.48 (s, 1 H, CH_2=), 6.12 (s, 1 H, CH_2=), 6.94 (s, 4 H, ArH), 7.06 (s, 2 H, ArH), 7.39 (d, 6 H, ArH), 7.41 (s, 2 H, ArH), 7.60 (dd, 12 H, ArH). ^{13}C NMR ($CDCl_3$): δ 18.30, 28.44, 30.80, 31.33, 31.62, 32.44, 32.90, 33.48, 34.88, 39.77, 40.15, 47.28, 64.87, 67.02, 119.19, 121.81, 124.68, 124.90, 128.43, 131.51, 134.94, 136.30, 141.99, 142.04, 144.02, 149.73, 156.16, 156.77, 167.20, 167.88. HiRes-MALDI: 1853.11 $[M + Na]^+$. Anal. Calcd for $C_{117}H_{150}N_6O_{12}$ (1830.46): C 76.77, H 8.15, N 4.59. Found: C 76.35, H 8.23, N 4.40.

Poly{3-(3-{3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino]-5-[3-(*tert*-butyloxycarbonylamino)propyl]benzoyl}amino)propyl-5-(3-{3,5-bis[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)propyl]benzoyl}amino)-propylbenzyl Methacrylate} (23a). According to procedure B: monomer **22** (0.30 g) and DMF (75 μL) were used. Polymerization at 70 °C for 14 h. Chromatographic separation yielded **23a** (0.25 g, 83%) as a slightly greenish solid. ^{1}H NMR ($CDCl_3$, 500 MHz): δ 0.92 (br, 3 H, CH_3), 1.28 (br, 63 H, CCH_3), 1.68 (br, 8 H, CH_2), 1.87 (br, 4 H, CH_2), 2.46 (br, 12 H, CH_2Ph), 3.05 (br, 8 H, CH_2-NH), 3.37 (br, 4 H, CH_2NH), 4.02 (br, 3 H, *CH*CH_2), 4.26 (br, 6 H, CH_2O), 4.86 (br, 4 H, NH), 7.01 (br, 5 H, ArH), 7.25 (br, 6 H, ArH), 7.49 (br, 16 H, ArH). ^{13}C NMR ($CDCl_3$, 500 MHz): δ 28.58, 31.29, 31.71, 32.78, 34.88, 40.08, 40.64, 47.50, 67.26, 79.80, 119.27, 121.58, 121.90, 124.72, 125.15, 131.43, 135.21, 138.77, 141.99, 144.24, 145.05, 149.86, 156.24, 156.81, 157.58, 168.65.

Poly{3-(3-{3-[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino]-5-[3-(amino)propyl]benzoyl}amino)propyl-5-(3-{3,5-bis[3-(2,7-di-*tert*-butyl-9-fluorenylmethoxycarbonylamino)-propyl]benzoyl}amino)propylbenzyl Methacrylate *x* HCl} (23b). According to procedure C: 25% HCl (0.3 mL), THF (10 mL), and **23a** (0.10 g) were used. Evaporation of the solvent yielded **23b** (80 mg, 85%) as a slightly greenish solid. ^{1}H NMR (d-DMF, 500 MHz): δ 0.78 (br, 3 H, CH_3), 1.26 (br, 54 H, CCH_3), 1.77 (br, 6 H, CH_2), 1.92 (br, 4 H, CH_2), 2.02 (br, 2 H, CH_2), 2.58 (br, 12 H, CH_2Ph), 2.87 (br, 2 H, CH_2NH), 3.10 (br, 6 H, CH_2NH), 3.29 (br, 4 H, CH_2NH), 4.10 (br, 3 H, *CH*CH_2), 4.26 (br, 6 H, CH_2O), 7.04 (br, 6 H, ArH), 7.32 (br, 6 H, ArH), 7.61 (br, 15 H, ArH). ^{13}C NMR (d-DMF, 500 MHz): δ 28.49, 30.84, 31.39, 32.14, 34.66, 39.27, 40.53, 47.33, 66.66, 119.39, 122.16, 124.71, 125.16, 131.68, 134.84, 138.70, 142.24, 144.57, 149.98, 157.58, 168.70.

Poly{3-(3-{3-[3-(amino]-5-[3-(*tert*-butyloxycarbonylamino)-propyl]benzoyl}amino)propyl-5-(3-{3,5-bis[3-(amino)propyl]-benzoyl}amino)propylbenzyl Methacrylate x 3HCl} (23c). According to procedure D: 25% aqueous piperidene (2.0 mL), DMF (20 mL), and **23a** (0.10 g) were used to yield **18c** (60 mg, 85%) as a viscous oil. ^{1}H NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 0.82 (br, 3 H, CH_3), 1.35 (br, 9 H, CCH_3), 1.70 (br, 2 H, CH_2), 1.88 (br, 4 H, CH_2), 2.01 (br, 6 H, CH_2), 2.57 (br, 12 H, CH_2Ph), 2.92 (br, 4 H, CH_2NH), 3.12 (br, 2 H, CH_2NH), 3.30 (br, 6 H, CH_2NH), 4.82 (br, 2 H, CH_2O), 6.97 (br, 4 H, ArH), 7.48 (br, 5 H, ArH). ^{13}C NMR ($CDCl_3$/CD_3OD, 500 MHz): δ 28.48, 30.77, 31.10, 31.98, 33.02, 39.11, 39.70, 78.73, 124.72, 125.17, 128.37, 131.48, 134.79, 140.96, 141.24, 142.21, 142.60, 157.04, 162.50, 168.70.

Acknowledgment. This work was in part supported by the German Science Foundation (Sfb 448, TP A1), which is gratefully acknowledged. We thank M. Colussi, ETHZ, for his competent help with the molar mass measurements. Prof. A. Zhang, Zhenzhou University and ETHZ, is thanked for his continued interest in this work and helpful discussions.

References and Notes

(1) For some examples, see: Freudenberger, R.; Claussen, W.; Schlüter, A. D.; Wallmeier, H. *Polymer* **1994**, *35*, 4496−4501. Percec, V.; Ahn, C. H.; Ungar, G.; Yeardley, D. J. P.; Möller, M.; Sheiko, S. S. *Nature (London)* **1998**, *391*, 161−164. Ouali, N.; Mery, S.; Skoulios, A.; Noirez, L. *Macromolecules* **2000**, *33*, 6185−6193. Shu, L.; Schäfer, T.; Schlüter, A. D. *Macromolecules* **2000**, *33*, 4321−4328. Buchowicz, W.; Holerca, M. N.; Percec, V. *Macromolecules* **2001**, *34*, 3842−3848. Grayson, S. M.; Fréchet, J. M. J. *Macromolecules* **2001**, *34*, 6542−6544. Andreopoulou, A. K.; Kallitsis, J. K. *Macromolecules* **2002**, *35*, 5808−5815. Malkoch, M.; Carlmark, A.; Woldegiorgis, A.; Hult, A.; Malmstroem, E. E. *Macromolecules* **2004**, *37*, 7491−7496. Cheng, C. X.; Tang, R. P.; Zhao, Y. L.; Xi, F. *J. Appl. Polym. Sci.* **2004**, *91*, 2733−2737. Kasemi, E.; Zhuang, W.; Rabe, J. P.; Fischer, K.; Schmidt, M.; Colussi, M.; Keul, H.; Yi, D.; Cölfen, H.; Schlüter, A. D. *J. Am. Chem. Soc.* **2006**, *128*, 5091−5099.

(2) For reviews, see: Schlüter, A. D.; Rabe, J. P. *Angew. Chem., Int. Ed.* **2000**, *39*, 864−883. Zhang, A.; Shu, L.; Bo, Z.; Schlüter, A. D. *Macromol. Chem. Phys.* **2003**, *204*, 328−339. Frauenrath, H. *Prog. Polym. Sci.* **2005**, *30*, 325−384. Schlüter, A. D. *Top. Curr. Chem.* **2005**, *245*, 151−191.

(3) Al-Hellani, R.; Schlüter, A. D. *PMSE Prepr.* **2004**, *91*, 387−388.

(4) Al-Hellani, R.; Schlüter, A. D. *Helv. Chim. Acta*, in press.

(5) For example, see: Malkoch, M.; Thibault, R. J.; Drockenmuller, E.; Messerschmidt, M.; Voit. B.; Russell, T. P.; Hawker, C. J. *J. Am. Chem. Soc.* **2005**, *127*, 14942−14949. Klok, H.-A. *J. Polym. Sci., Part A: Polym. Chem.* **2005**, *43*, 1−14. For orthogonally protected dendrimers, see: Grayson, S. M.: Jayaraman, M.; Fréchet, J. M. *J. Am. Chem. Soc., Div. Polym. Chem. Polym. Prepr.* **2000**, *41*, 167−168. Glauser, T.; Stancik, C. M.; Möller, M.; Voytek, S.; Gast, A. P.; Hedrick, J. L. *Macromolecules* **2002**, *35*, 5774−5781. Steffensen, M. B.; Simanek, E. E. *Angew. Chem., Int. Ed.* **2004**, *43*, 5178−5180.

(6) Greene, T. W.; Wuts, P. G. M. *Protective Groups in Organic Synthesis*; Wiley: New York, 1991.

(7) The term surface is meant to describe the collection of all terminal functional groups of an individual macromolecule which on time average will lie on a cylinder representing the dendronized polymer's shape. This use is not to be compared with that applied to solids. To avoid any confusion, the term "surface" is put in quote throughout.

(8) For a similar observation, see: Chinchilla, R.; Dodsworth, D. J.; Nájera, C.; Soriano, J. M. *Bioorg. Med. Chem. Lett.* **2002**, *12*, 1817−1820.

(9) For an investigation of the solubility of Fmoc vs Fmoc* decorated small molecules, for example, see: Stigers, K. D.; Koutroulis, M. R.; Chung, D. M.; Nowick, J. S. *J. Org. Chem.* **2000**, *65*, 3858−3860.

(10) Zhang, A.; Zhang, B.; Wächtersbach, E.; Schmidt, M.; Schlüter, A. D. *Chem.—Eur. J.* **2003**, *9*, 6083−6092.

(11) As far as this can be said for the given signal-to-noise ratio.

(12) Fmoc* is normally removed under basic conditions which leads to 2,3-di(*tert*-butyl)dibenzofulvene and is stable under even more acidic conditions than the ones applied here. The products of an eventual decomposition under the conditions applied were not investigated but may either be the same fulvene or 2,7-di(*tert*-butyl)fluorenylmethanol, both of which could easily be detected by TLC and were not observed. Actually there was no low molar mass product observed at all.

(13) Al-Hellani, R.; Barner, J.; Rabe, J. P.; Schlüter, A. D. *Chem.—Eur. J.* **2006**, *12*, 6542−6551.

MA061957A