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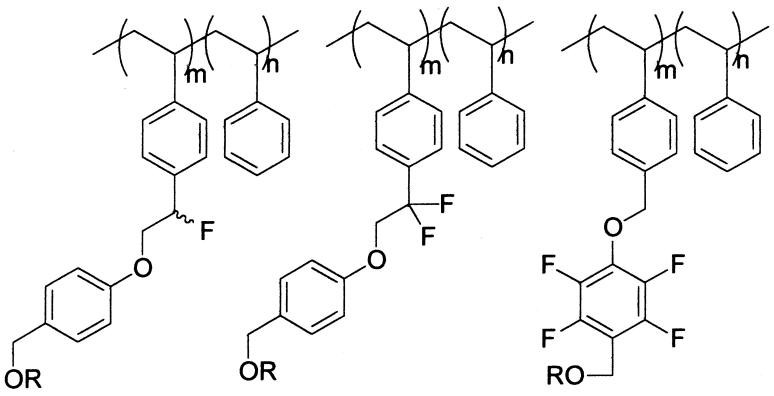

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Reaction Monitoring in LPOS by ^{19}F NMR. Study of Soluble Polymer Supports with Fluorine in Spacer or Linker Components of Supports

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Various soluble polystyrene supports with fluorinated spacer or linker were prepared and studied by ^{19}F NMR for their use in LPOS reaction monitoring. Among three types of systems studied, the perfluoro Wang linker was found to be most efficient for this purpose. Substrates could be easily anchored to and cleaved from this new support-bound linker. The anchoring of the linker and the substrates on the polymer led to significant changes in the fluorine resonances. Therefore, the progress of these reactions could be both monitored and quantified. On the other hand, the chemical transformations on the anchored substrates led only to moderate changes in the fluorine resonances. Nevertheless, the reaction progress could also be monitored in this case. After cleavage of products, the polymer supports were recovered without loss in loading. Membrane separation technology was used to purify some polymer-bound products as well as to obtain the polymer-free cleaved product.

Introduction

Solid-phase organic synthesis (SPOS) has emerged as a powerful tool for combinatorial and parallel synthesis strategies. SPOS is a useful and often complementary alternative to conventional solution-phase synthesis.[1] Tedious sample preparation procedures and complex analytical data of substrates anchored on polymer are major problems associated with the available analytical techniques used in monitoring chemical reactions on polymer bound moieties. In view of its powerful applications in organic chemistry, NMR spectroscopy appears to be the analytical tool of choice for supported organic synthesis and combinatorial chemistry as well.[2] However, conventional ^{1}H and ^{13}C NMR spectroscopy in combination with magic angle spinning of compounds attached to polymer supports often give broad resonances and is dominated by signals from the polymer support. Commonly used supports do not contain fluorine and as a result ^{19}F NMR could offer an opportunity to monitor the reactions on supports with fluorine on either the spacer or the linker motifs. The nucleus ^{19}F has the advantage of 100% natural abundance and a high magnetogyric ratio of about 0.94 times that of ^{1}H. The chemical shift range is 20 or more times that of hydrogen, so that the resonances of different fluorine nuclei are usually well separated. Furthermore, spectral positions are sensitive to the environments of fluorine atoms.[3] Early in 1980, the ^{19}F NMR approach for studying the Merrifield solid-phase peptide synthesis reported the use of fluorinated amino acid protecting groups as probes in NMR analysis.[4] A similar case study was reported later in 1996 for the S_NAr reaction on support-bound fluorinated substrates.[5] In the recent past, fluorinated building blocks were used for the quantification of resin loading and the encoding of combinatorial libraries.[6] In a few cases, fluorinated linkers have been successfully utilized as internal standards for quantification or monitoring of reactions performed on solid support such as amide bond formation, esterification, glycosidation, and cleavage of products.[7] It has to be noted that the chemical shift differences decreased rapidly with the distance between the fluorine atom and the end of the chain.

As an alternative to the commonly employed cross-linked resin supports, researchers have turned to soluble polymers which possess benefits such as direct NMR monitoring of the reaction, more rapid product purification, solution-phase reaction rates, and facile removal of excess reagents and unbound reaction byproducts using rapid filtration of the precipitated solid support.[8] As part of our ongoing research efforts in soluble polymer supported synthesis, we embarked on a program to prepare several selected non-cross-linked polystyrenes with fluorinated spacers or linkers, and validate their use in parallel synthesis with facile reaction monitoring by ^{19}F NMR analysis. Previously, a soluble polystyrene polymer with a perfluorinated backbone was prepared, but has never been utilized in liquid-phase organic synthesis (LPOS).[9] This article presents our results on the preparation of non-cross-linked polystyrenes (NCPS) with a monofluoro spacer, a difluoro spacer, or a perfluoro Wang linker (Figure 1).

Further, their utilization in supported organic synthesis has been verified by performing several reactions on the polymer-bound acrylic acid moiety. Ultrafiltration technique was

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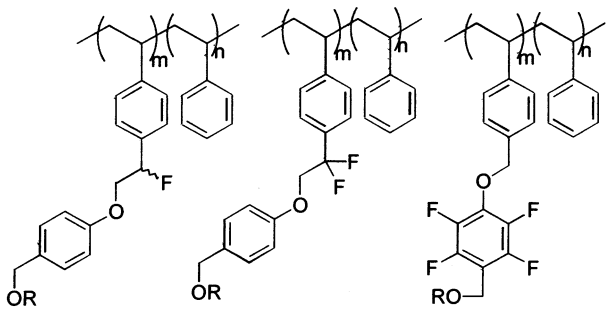
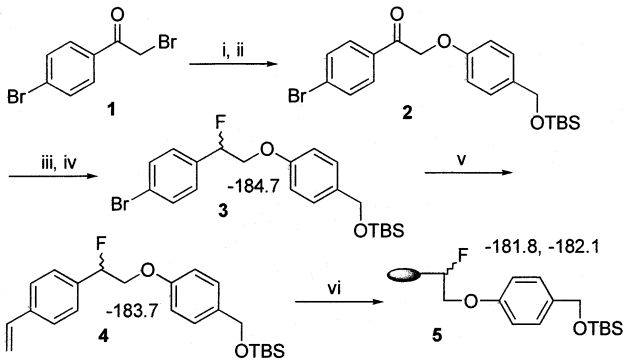


Figure 1. Structures of non-cross-linked polystyrenes (NCPS) with a monofluoro spacer, a difluoro spacer, or a perfluoro Wang linker.

Scheme 1[a]



[a] Key: (i) 4-hydroxybenzyl alcohol, K_2CO_3, CH_3CN, reflux, 8 h, 96%; (ii) TBS−Cl, imidazole, CH_2Cl_2, 0 °C to room temperature, 2 h, 98%; (iii) $NaBH_4$, CH_3OH, 0 °C to room temperature, 2 h, 95%; (iv) DAST, CH_2Cl_2, −70 °C, 30 min, 88%; (v) $Bu_3Sn(CH{=}CH_2)$, $Pd(PPh_3)_4$, toluene, 100 °C, 12 h, 95%; (vi) styrene, AIBN, toluene, 80 °C, 40 h, 35%.

utilized for the purification of polymer-bound products after each reaction and for the retention of polymer after cleavage of the product. The same reaction scheme was performed on Merrifield resin and hence validating the utility of the perfluoro Wang linker in chemistry on solid-supports.

NCPS with Monofluoro Spacer. This new polymer support could be prepared from the synthetic monomer **4**. The synthesis of **4** was achieved in five steps from *p*-bromophenacyl bromide (**1**) with 70% overall yield. Bromide **1** was treated with 4-hydroxybenzyl alcohol in the presence of a base, followed by the protection of benzyl alcohol as the silyl ether to yield the compound **2** quantitatively. Reduction of the ketone **2** was performed with $NaBH_4$, and the resulting alcohol was converted to the fluoro derivative **3** by the known dehydroxy-fluorination reaction by DAST.[10] The Stille reaction on compound **3** gave the styrene monomer **4** which was used to prepare the soluble polymer support. Styrene and the monomer **4** (9:1) were reacted by a radical copolymerization method[11] to give the soluble, linear, and non-cross-linked polystyrene **5** in 35% yield (Scheme 1).

The loading capacity was determined from the ^1H NMR analysis of the polymer, as reported in the literature for similar compounds.[11] A value of 1 mmol/g was obtained. Unfortunately, the ^{19}F NMR analysis of this polymer showed a broad and twin-hump signal which could be attributed to the remote chiral recognition of the fluorine on benzylic chiral carbon with the backbone chirality of the polystyrene. All our attempts to analyze the polymer in various deuterated solvents at different temperatures failed to solve the problem of line broadening in ^{19}F NMR spectra. At this stage, we decided to anchor acrylic acid on the support and perform several reactions to deduce chemical shift difference in ^{19}F NMR analysis of product-bound polymers (Scheme 2).

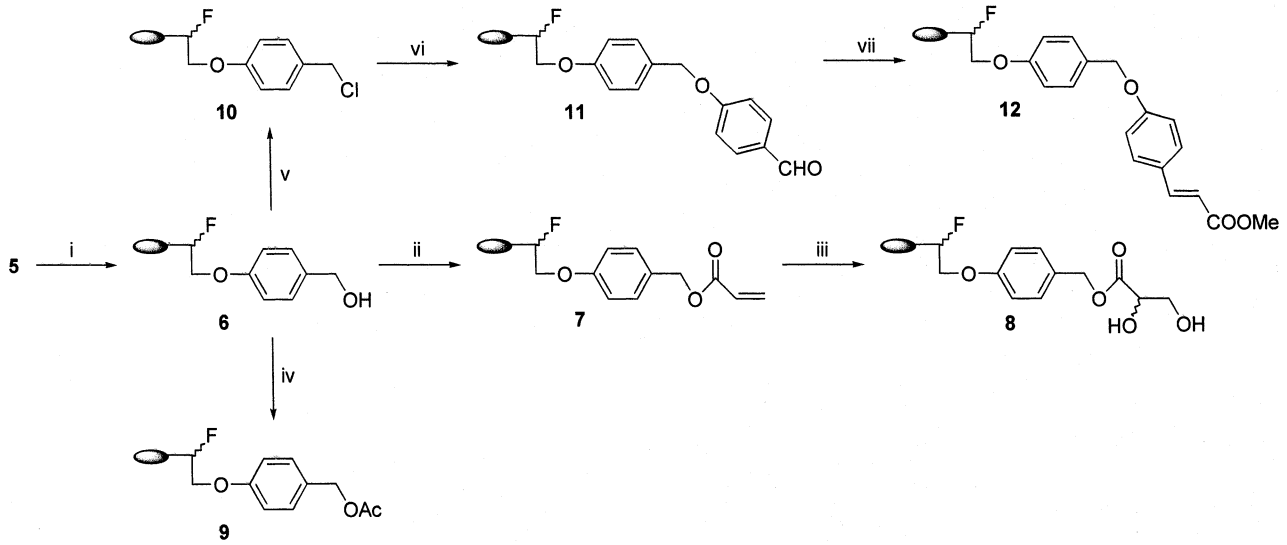
For this purpose, polymer **5** was de-*O*-silylated to give the alcohol **6** and it was treated with acryloyl chloride to provide the acrylic acid bound polymer **7**. The dihydroxylation reaction of polymer **7** gave the glyceric acid on polymer **8**. Additional standard reactions were performed on the polymer alcohol **6** to give acetate-, chloro-, aldehyde-, and olefin-bound supports (**9**−**12**). All these products on polymer were well characterized by their ^1H and ^{13}C NMR analysis. But the ^{19}F NMR analysis showed no change in the resonance from all the anchored products **5**−**12**. We concluded that the line broadening of the signals could be the main reason for the inability to see small chemical shift differences. At this juncture, we prepared a cross-linked version of **5** from monomer **4** and styrene using 2% divinylbenzene as cross-linking agent. MAS ^{19}F NMR analysis of this polymer resulted in a similar twin-hump broad signal in the spectrum. We envisioned that the resulting NMR problem could be solved using a support with fluorine attached to achiral carbons, and in this regard, we proceeded to prepare NCPS with difluoromethylene spacer.

NCPS with Difluoro Spacer. Synthesis of styrene monomer **15** was achieved following Scheme 3. Phenacyl bromide **1** on rigorous deoxo-difluorination with DAST at room temperature for 8 days gave the difluoro derivative **13** in moderate yield (68%).[12] Compound **13** was reacted with the Wang linker in the presence of a base to give compound **14** in 45% yield. Protection of alcohol **14** as the silyl ether followed by a Stille reaction afforded the desired styrene monomer **15** in 25% overall yield from phenacyl bromide **1**.

The soluble polymer support **16** was prepared by radical copolymerization[11] of monomer **15** and styrene (1:9). The loading of the polymer support was determined by ^1H NMR analysis and a value of 0.5 mmol/g was obtained. ^{19}F NMR analysis showed a single broad signal in the spectrum, and the earlier problem of the twin-hump pattern was solved. Scheme 4 depicts various reactions performed on the polymer **16**.

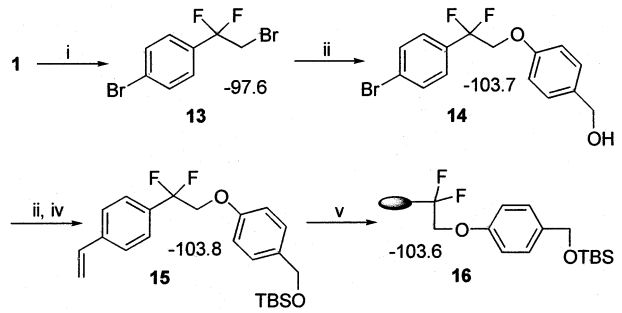
All the polymer-bound products were characterized by ^1H and ^{13}C NMR analysis. Unfortunately, we did not find any difference in the fluorine resonances from all the product-bound polymers. Though it was anticipated in the beginning that the fluorine could be sensitive to remote structural changes, it is now clear from our experience that the fluoro spacers, being far away from the reaction center, cannot be used as an analytical probe for monitoring the reactions on support. To delineate this further, we prepared the cross-linked polymer of **16** from the respective monomers styrene and **15** using 2% divinylbenzene as cross-linking agent. Acrylic acid was anchored on this cross-linked polymer support and it was reacted with thiophenol. The solid supports were analyzed by ^{19}F NMR and no change in the position of the fluorine signals was observed. At this time period, two groups reported the use of monofluoro Wang type linkers in solid-phase organic synthesis.[7] In continuation of our efforts to find a strategic position for the fluorine atom in the polymer support motifs, we decided to investigate the

Scheme 2[a]



[a] Key: (i) TBAF, THF, 0 °C to room temperature, 6 h; (ii) acryloyl chloride, DIPEA, CH_2Cl_2, 0 °C to room temperature, 18 h; (iii) OsO_4, NMO, THF/acetone/H_2O, rt, 24 h; (iv) Ac_2O, TEA, CH_2Cl_2, rt, 3 h; (v) $SOCl_2$, CH_2Cl_2, 0 °C to room temperature, 6 h; (vi) *p*-hydroxybenzaldehyde, K_2CO_3, DMF, 60 °C, 12 h; (vii) $Ph_3P{=}CHCOOMe$, toluene, 80 °C, 6 h.

Scheme 3[a]



[a] Key: (i) DAST, rt, 8 days, 68%; (ii) 4-hydroxybenzyl alcohol, K_2CO_3, DMF, 60 °C, 12 h, 45%; (iii) TBS−Cl, imidazole, CH_2Cl_2, 0 °C to room temperature, 2 h, 94%; (iv) $Bu_3Sn(CH{=}CH_2)$, $Pd(PPh_3)_4$, toluene, 100 °C, 12 h, 91%; (v) styrene, AIBN, toluene, 80 °C, 40 h, 32%.

possibility of linking perfluoro Wang linker to soluble supports and study the reaction products on these supports.

NCPS with Perfluoro Wang Linker. Tetrafluorophenol was treated with formaldehyde following the literature procedure[15] to obtain the perfluoro Wang linker **21**. Attaching this linker onto NCPS (1 mmol/g) in the presence of a base delivered the polymer **22** in good yield with no loss in loading as detected from their ^{1}H NMR analysis. ^{19}F NMR analysis showed two nearly sharp signals for the two identical sets of fluorine atoms. Acrylic acid was anchored to this linker by treating the polymer with acryloyl chloride in the presence of Hunig's base to give the polymer support **23** (Scheme 5).

Various reactions were performed on olefin **23** (Scheme 6). Changes in the fluorine NMR signals were observed for the product-bound polymers **22**−**27**.[13] The differences in the resonances for the products **21**−**23** were large enough (∼2 ppm) to monitor and quantify the reaction progress (Figure 2). But, for products **24**−**27**, the chemical shift differences were small (∼0.2 ppm).

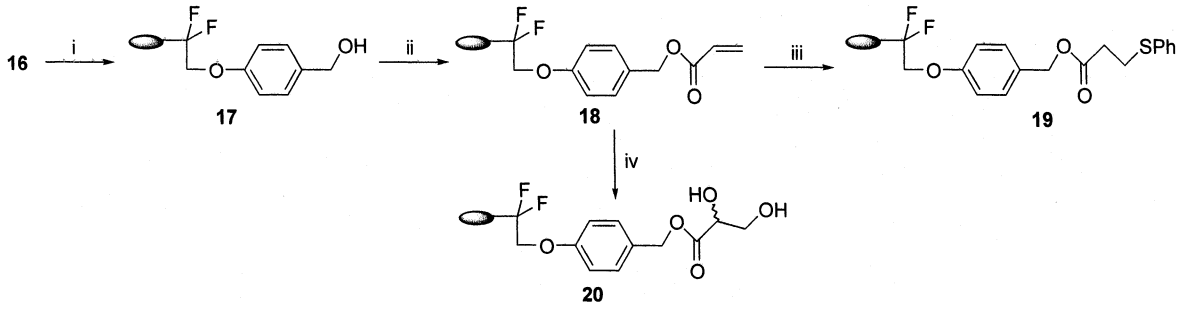
In such cases, we were able to monitor the product formation by the appearance of shoulder peaks; quantification of the reaction progress was not possible, as the fluorine signals for reactant and product polymers were very close (Figure 3).

On the basis of the classical supported chemistry approach, the products were cleaved from the supports by transesterification using catalytic amounts of $NaOCH_3$ in THF/CH_3-OH (Scheme 7). All the cleaved products **28**−**30** were purified by flash chromatography on silica gel, and the yields were 35−55% from acrylic-acid-bound polymer **22**.[16] The products **29** and **30** were obtained as mixtures of diastereomers. The polymer support **22** was recovered after each cleavage reaction and was characterized by NMR analysis (^{1}H, ^{19}F, and ^{13}C). The recovered polymer-anchored linker **22** was pure, and no loss in loading was detected in the NMR analysis of the polymer.

It is generally believed that soluble polymeric supports, apart from their advantages, may be difficult to separate from the reaction mixture. Precipitation is frequently used in soluble polymer chemistry to purify the polymer from low-molecular-weight impurities. This, however, is not suitable for multistep synthesis, because often impurities remain trapped in the polymer. In addition, large solvent volumes are required to perform quantitative precipitations, and hence automation of the process is difficult. Therefore, we decided to examine ultrafiltration for the separation of the polymer from the reaction mixtures (Scheme 8).

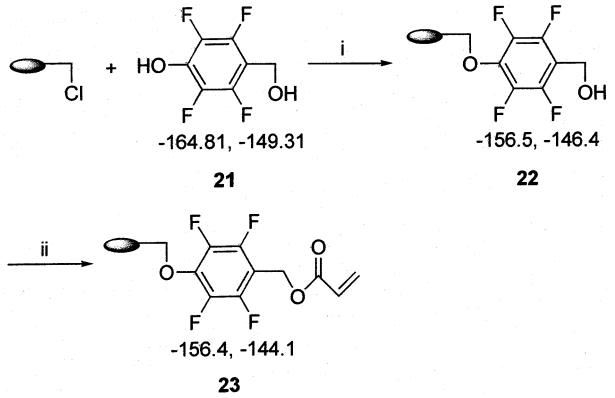
The reactions were performed in a classical round-bottomed flask, and the reaction mixtures were washed to remove any acidic or basic reagents before loading into the membrane filtration cell. Filtrations and washings were done through polyaramide membrane with a cutoff value of 10 kD. The polymer retention was quite high and found to be more than 99.5% after each filtration. The purities of polymers **22**−**24** were comparable (by NMR analysis) to those of the product-bound polymers obtained by precipitation methods. The final product isoxazole **28** was then cleaved by base-catalyzed transesterification from the poly-

Scheme 4[a]



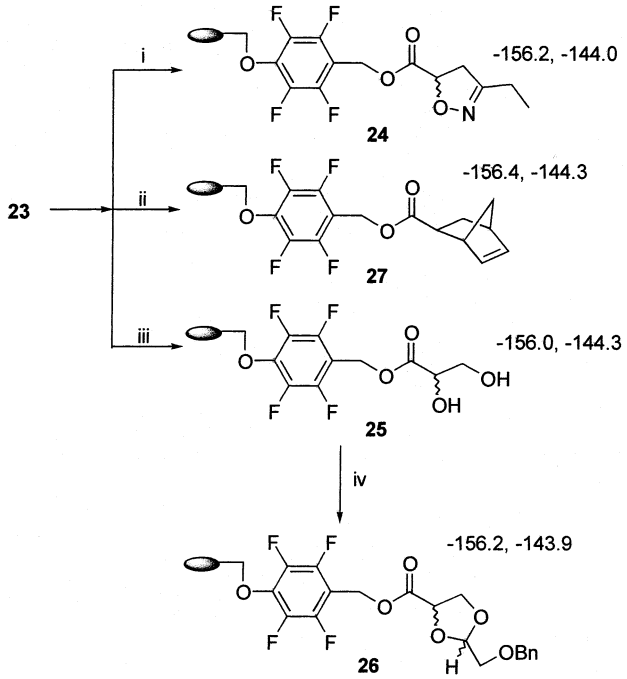
[a] Key: (i) TBAF, THF, 0 °C to room temperature, 6 h; (ii) acryloyl chloride, DIPEA, CH_2Cl_2, 0 °C to room temperature, 18 h; (iii) thiophenol, TEA, CH_2Cl_2, rt, 6 h, (iv) OsO_4, NMO, THF/acetone/H_2O, rt, 24 h.

Scheme 5[a]



[a] Key: (i) K_2CO_3, DMF, 65 °C, 12 h; (ii) acryloyl chloride, DIPEA, CH_2Cl_2, 0 °C to room temperature, 18 h.

Scheme 6[a]



[a] Key: (i) 1-Nitropropane, phenyl isocyanate, TEA, toluene, rt to 80 °C, 6 h; (ii) cyclopentadiene, toluene, 120 °C, 6 h; (iii) OsO_4, NMO, THF/acetone:H_2O, rt, 24 h; (iv) $BnOCH_2CH(OEt)_2$, *p*-TSA, toluene, 70 °C, 12 h.

mer **24**. A final separation using membrane afforded **28** in 45% yield and in high purity as confirmed by NMR analysis. The retained polymer **22** (>98%) was pure with no loss in loading as analyzed by NMR.

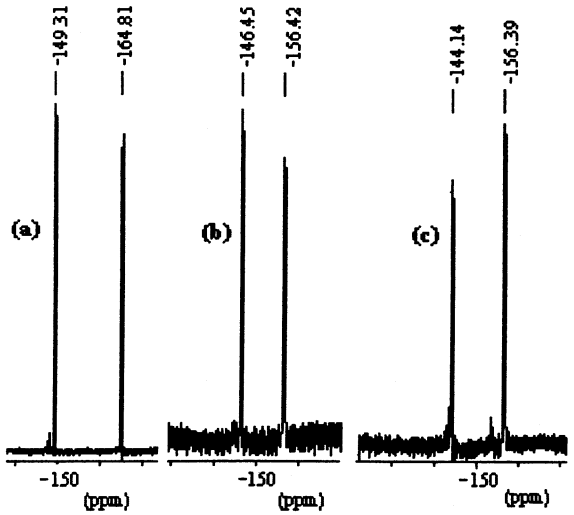


Figure 2. ^{19}F NMR spectra of product **21** (a) and product-bound polymers **22** (b) and **23** (c).

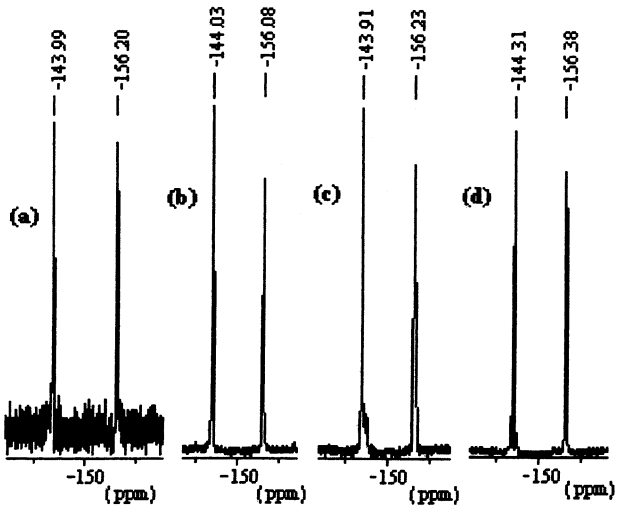
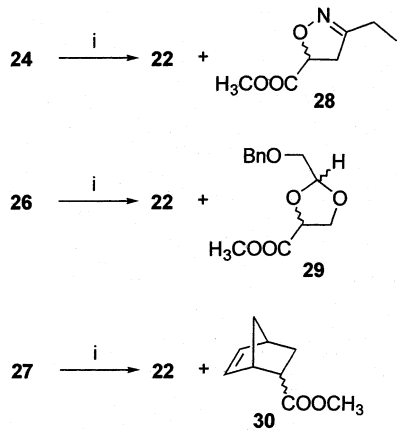


Figure 3. ^{19}F NMR spectra of product-bound polymers **24** (a), **25** (b), **26** (c), and **27** (d).

In conclusion, we have shown that the fluorine in the spacer components of polymer supports cannot be used as a probe for facile reaction monitoring in LPOS by ^{19}F NMR analysis. However, only the tetrafluoro Wang linker appeared proximal enough to detect structural changes in the substrate components of the supports. The use of this linker toward the reaction monitoring by ^{19}F NMR is reported for the first time. Ultrafiltration has been well adopted for purifying

Scheme 7[a]



[a] Key: (i) $NaOCH_3$, THF/CH_3OH, rt, 3 h.

products anchored to supports. In addition, high retention of the polymer supports was observed in ultrafiltration, qualifying these supports suitable for membrane separation techniques. Cleavage of products by base-catalyzed transesterification in methanol demonstrated the orthogonal use of these soluble polymeric supports. Use of this novel linker should offer new opportunities in the parallel synthesis and combinatorial chemistry arena.

Experimental Section

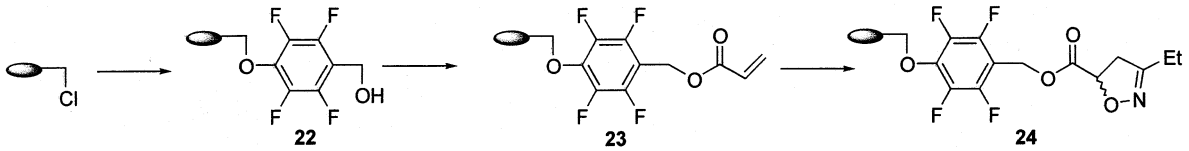
General Remarks. The reactions were performed in oven-dried glassware under nitrogen atmosphere unless mentioned otherwise. All the anhydrous solvents were prepared by standard procedures. Solvents for extraction and chromatography were of technical grade and used after distillation. PetEther refers to the fraction boiling in the range 40−60 °C. Organic extracts were dried over anhydrous $MgSO_4$. Evaporation and removal of organic solvents were done by a Buchi RotaVapor connected to a water aspirator. TLC analysis was carried out on aluminum sheets precoated (0.2 mm) with E. Merck silica gel 60 F_{254}. The spots were detected by using UV light (254 nm), blowing I_2, or dipping into anisaldehyde/sulfuric acid solution followed by blowing hot air. The products of reaction were purified by flash chromatography using E. Merck silica gel F (40−60 μm), and found to be homogeneous by TLC and NMR analysis. All the new compounds were characterized from their NMR and mass spectral data, and were in accordance with the assigned structures. Melting points were measured on a Reichert melting point apparatus and are uncorrected. NMR spectra (gel and solution phase) were recorded in $CDCl_3$ (unless mentioned otherwise) using a Bruker AMX400 spectrometer operating at 400 MHz for proton, 100 MHz for carbon, and 376.5 MHz for fluorine. The internal standards were TMS/residual $CHCl_3$ (^{1}H NMR), $CDCl_3$ (^{13}C NMR), and $CFCl_3$ (^{19}F NMR). All the chemical shifts are expressed in ppm, and the coupling constants are reported in Hz. MAS NMR analysis was carried at GlaxoWellcome Research and Development, Stevenage, U.K. HRMS data were obtained using a Varian MAT311 and were run at CRMPO, Rennes, France. Polymer purification by membrane separations was done using Membra-Sep filtration cells (capacity 75 mL) and polyaramide membranes (cutoff: 10 kD). These accessories are available from MembraPure GmbH, Bodenheim, Germany. All the chemicals were purchased from commercial suppliers and used as received. *p*-Bromophenacyl bromide,[14] 2,3,5,6-tetrafluoro-4-hydroxybenzyl alcohol,[15] and NCPS (non-cross-linked polystyrene)[11] were prepared following the literature procedures.

1-(4-Bromo-phenyl)-2-[4-(*tert*-butyl-dimethyl-silanyloxymethyl)-phenoxy]-ethanone (2). Anhydrous K_2CO_3 (1.2 g, 8.6 mmol) and 4-hydroxybenzyl alcohol (1.07 g, 8.6 mmol) were added to a stirred solution of 4-bromophenacyl bromide **1** (2 g, 7.2 mmol) in anhydrous CH_3CN (75 mL). The resulting solution was heated and stirred under solvent reflux for 8 h and cooled to room temperature. The solvent was evaporated, and the residue was partitioned (EtOAc/H_2O, 1:1, 100 mL). The aqueous layer was extracted with EtOAc (2 × 50 mL), and the combined organic phase was washed with water (50 mL) and brine (50 mL). Evaporation of solvent afforded a crude yellow solid, which was purified by flash chromatography (EtOAc/PetEther, 1:6→1:3) to give the title compound as a pale yellow solid characterized as 1-(4-bromo-phenyl)-2-(4-hydroxymethyl-phenoxy)-ethanone (2.2 g, 96%). MP = 143−145 °C. R_f = 0.52 (PetEther/EtOAc, 3:2). ^{1}H NMR (CD_3COCD_3): δ 6.92 (d, J = 8.6, 2H), 6.67 (d, J = 8.4, 2H), 6.18 (d, J = 8.6, 2H), 5.85 (d, J = 8.6, 2H), 4.40 (s, 2H), 3.46 (s, 2H). ^{13}C NMR (CD_3COCD_3): δ 192.9, 156.5, 134.4, 133.1, 131.2, 129.1, 127.2, 127.1, 113.5, 69.5, 62.5. HRMS (EI): calcd for $C_{15}H_{13}O_3Br$ (M^+), 320.0048; found, 320.0031.

Imidazole (0.51 g, 7.5 mmol) was added to a stirred solution of 1-(4-bromo-phenyl)-2-(4-hydroxymethyl-phenoxy)-ethanone (2 g, 6.2 mmol) and *tert*-butyldimethylsilyl chloride (1 g, 6.6 mmol) in anhydrous CH_2Cl_2 (100 mL) at 0 °C. The resulting solution was allowed to warm to room temperature and stirred for 2 h. The reaction mixture was diluted by adding CH_2Cl_2 (50 mL) and washed with a saturated aqueous solution of NH_4Cl. The organic layer was washed with water (50 mL) and brine (50 mL). Evaporation of solvent afforded a crude oil, which, on flash chromatographic purification (EtOAc/PetEther, 6:94→10:90), gave **2** as a pale yellow solid (2.66 g, 98%). MP = 81−82 °C. R_f = 0.57 (PetEther/EtOAc, 3:1). ^{1}H NMR: δ 7.86 (d, J = 8.4, 2H), 7.62 (d, J = 8.4, 2H), 7.24 (d, J = 8.4, 2H), 6.89 (d, J = 8.6, 2H), 5.19 (s, 2H), 4.68 (s, 2H), 0.94 (s, 9H), 0.10 (s, 6H). ^{13}C NMR: δ 193.9, 156.8, 134.7, 133.2, 132.0, 129.7, 129.0, 127.5, 114.4, 70.9, 64.4, 25.9, 18.3, −5.2. HRMS (EI): calcd for $C_{21}H_{27}O_3BrSi$ (M^+), 434.0912; found, 434.0909.

{4-[2-(4-Bromo-phenyl)-2-fluoro-ethoxy]-benzyloxy}-*tert*-butyl-dimethyl-silane (3). Sodium borohydride (0.1 g, 2.6 mmol) was slowly added over 15 min to a stirred solution of **2** (2.5 g, 5.7 mmol) in anhydrous CH_3OH (50 mL) at 0 °C. The resulting solution was allowed to warm to room temperature and stirred for 2 h. Solvent was removed and the resulting slurry was partitioned in Et_2O/H_2O (1:1, 100 mL). The water layer was extracted with Et_2O (2 × 50 mL), and the combined organic phase was washed with water (50 mL) and brine (50 mL). Removal of solvent provided a crude oil, which on purification by column chromatography (EtOAc/PetEther, 6:94→12:88) afforded a clear low-melting

Scheme 8



solid (2.4 g, 95%), which was characterized as 1-(4-bromophenyl)-2-[4-(*tert*-butyl-dimethyl-silanyloxymethyl)-phenoxy]-ethanol. $R_f = 0.48$ (PetEther/EtOAc, 4:1). ^1H NMR: δ 7.50 (d, $J = 8.4$, 2H), 7.32 (d, $J = 8.4$, 2H), 7.24 (d, $J = 8.6$, 2H), 6.86 (d, $J = 8.6$, 2H), 5.05 (dd, $J = 8.6$, 3.0, 1H), 4.68 (s, 2H), 4.05 (dd, $J = 9.6$, 3.3, 1H), 3.93 (dd, $J = 9.6$, 1, 1H), 0.94 (s, 9H), 0.10 (s, 6H). ^{13}C NMR: δ 157.2, 138.6, 134.3, 131.6, 127.9, 127.5, 121.9, 114.3, 73.0, 71.9, 64.5, 25.9, 18.3, −5.2. HRMS (EI): calcd for $C_{21}H_{29}O_3BrSi$ (M^+), 436.1069; found, 436.1063.

Diethylaminosulfur trifluoride (0.74 mL, 5.5 mmol) was slowly added to a stirred solution of silyl ether (vide supra) (2.2 g, 5 mmol) in anhydrous CH_2Cl_2 (50 mL) at −70 °C. The resulting solution was warmed to −50 °C and stirred for 30 min. The reaction was diluted with CH_2Cl_2 (50 mL) and quenched by adding 10% aqueous Na_2CO_3 solution (20 mL). The aqueous layer was extracted with CH_2Cl_2 (50 mL), and the combined organic phase was washed with water (50 mL) and brine (50 mL). Removal of solvent afforded a crude orange oil, which was purified by flash chromatography (EtOAc/PetEther, 2:98→8:92) to give a clear oil **3** (1.94 g, 88%). $R_f = 0.64$ (PetEther/EtOAc, 4:1). ^1H NMR: δ 7.53 (d, $J = 8.1$, 2H), 7.28 (d, $J = 8.1$, 2H), 7.24 (d, $J = 8.4$, 2H), 6.87 (d, $J = 8.4$, 2H), 5.68 (ddd, $^2J_{HF} = 47.8$, $J = 7.3$, 3.3, 1H), 4.68 (s, 2H), 4.24 (ddd, $^3J_{HF} = 18.0$, $J = 10.9$, 7.4, 1H), 4.08 (ddd, $^3J_{HF} = 26.9$, $J = 10.9$, 3.3, 1H), 0.94 (s, 9H), 0.10 (s, 6H). ^{13}C NMR: δ 157.1, 135.3 (d, $^2J_{CF} = 20.0$), 134.4, 131.7, 127.5, 127.4 (d, $^3J_{CF} = 6.4$), 122.9 (d, $^3J_{CF} = 2.4$), 114.3, 90.6 (d, $^1J_{CF} = 176.7$), 70.7 (d, $^2J_{CF} = 25.7$), 64.5, 25.9, 18.3, −5.2. ^{19}F NMR: δ −184.69. HRMS (EI): calcd for $C_{21}H_{28}O_2FBrSi$ (M^+), 438.1026; found, 438.1033.

***tert*-Butyl-{4-[2-fluoro-2-(4-vinyl-phenyl)-ethoxy]-benzyloxy}-dimethyl-silane (4).** Tributyl(vinyl)tin (3.8 mL, 13 mmol) was added to a stirred solution of **3** (1.9 g, 4.3 mmol) and $Pd(PPh_3)_4$ (0.5 g, 0.43 mmol) in degassed anhydrous toluene (50 mL) under argon atmosphere. The resulting solution was stirred at 100 °C for 12 h and cooled to room temperature. A 30% aqueous solution of KF (50 mL) and Et_2O (50 mL) was added, and the reaction mixture was stirred for 3 h. The aqueous layer was extracted with Et_2O (50 mL), and organic layers were pooled and washed successively with 10% aqueous ammonia (50 mL), water (50 mL), and brine (50 mL). Removal of solvent afforded a crude oil which, on purification by flash chromatography (EtOAc/PetEther, 1:99→6:94), gave a clear oil **4** (1.6 g, 95%). $R_f = 0.64$ (PetEther/EtOAc, 4:1). ^1H NMR: δ 7.47 (d, $J = 8.3$, 2H), 7.39 (d, $J = 8.3$, 2H), 7.26 (d, $J = 8.8$, 2H), 6.90 (d, $J = 8.8$, 2H), 6.72 (dd, $J = 17.6$, 10.9, 2H), 5.79 (d, $J = 17.6$, 1H),5.75 (ddd, $^2J_{HF} = 48.2$, $J = 7.7$, 2.9, 1H), 5.31 (d, $J = 10.9$, 1H), 4.70 (s, 2H), 4.28 (ddd, $^3J_{HF} = 17.4$, $J = 11.0$, 7.8, 1H), 4.12 (ddd, $^3J_{HF} = 28.6$, $J = 11.0$, 2.9, 1H), 0.96 (s, 9H), 0.11 (s, 6H). ^{13}C NMR: δ 157.3, 138.2 (d, $^3J_{CF} = 1.6$), 136.1, 135.7 (d, $^2J_{CF} = 19.2$), 134.3, 127.5, 126.4, 126.0 (d, $^3J_{CF} = 6.4$), 114.7, 114.4, 91.2 (d, $^1J_{CF} = 175.8$), 71.1 (d, $^2J_{CF} = 24.9$), 64.6, 25.9, 18.3, −5.2. ^{19}F NMR: δ −183.72. HRMS (EI): calcd for $C_{23}H_{31}O_2FSi$ (M^+), 386.2077; found, 386.2077.

Radical Co-Polymerization of 4 with Styrene. AIBN (0.03 g, 0.2 mmol) was added to a stirred solution of **4** (1.5 g, 3.88 mmol) and styrene (3.6 g, 34.9 mmol) in 40 mL of degassed anhydrous toluene. The resulting solution was stirred at 80 °C for 40 h and cooled to room temperature. The solution was concentrated to 10 mL and was added dropwise to a cooled (−40 °C) solution of CH_3OH (150 mL) over 15 min. The suspension of precipitated polymer in CH_3OH was stirred at room temperature for 20 min. The solid was collected by filtration and washed with CH_3OH (3 × 100 mL). The wet polymer was suck-dried and kept in a vacuum oven at 45 °C for 6 h to give a dry solid **5** (1.8 g, 35%). Loading capacity of the polymer was determined by ^1H NMR analysis. A value of 1 mmol/g was obtained. ^1H NMR: δ 7.27−6.30 (bh, Ar-*H*), 5.78−5.61 (bh, C*H*-F), 4.70 (bs, CH_2−OTBS), 4.25−4.01 (bh, CH_2−CHF), 1.95−1.15 (bh, C*H*CH_2), 0.96 (bs, CMe_3), 0.11 (bs, SiMe_2). ^{13}C NMR: δ 157.4, 145.2, 134.2, 127.9−125.5, 114.4, 91.2 (d), 71.0 (d), 64.6, 45.7−40.5, 25.9, 18.4, −5.2. ^{19}F NMR: δ −181.80, −182.17.

Cross-Linked Polystyrene 5a. A suspension copolymerization method as described in the literature was followed. [17] Poly(vinyl alcohol) (0.3 g) in deionized water (30 mL) was taken in a resin reactor equipped with a mechanical stirrer. The solution was stirred and argon was bubbled for 30 min. Bubbling was stopped and a solution of styrene (1.53 g, 14.67 mmol), monomer **4** (0.63 g, 1.63 mmol), divinyl benzene (50%, 0.085 g, 0.326 mmol), and AIBN (0.075 g) in THF/toluene (1:1, 10 mL) was added at 0 °C. The resulting suspension was stirred (350 rpm) under argon at 0 °C for 1 h and then at 70 °C for 36 h. The reaction mixture was cooled to room temperature. The fine solid polymer was filtered and washed successively with water, DMF, and methanol (3 × 50 mL). Polymer was dried at 80 °C under vacuum for 12 h to give a solid (0.6 g). ^{19}F MAS NMR ($CDCl_3/C_6F_6$); δ −159.6, −159.8.

Compound 6. A 1 M THF solution of Bu_4NF (7.5 mL, 7.5 mmol) was added to a stirred solution of polymer **5** (1.5 g, 1.5 mmol) in anhydrous THF (50 mL) at 0 °C. The resulting solution was stirred at room temperature for 6 h. Concentration of the reaction mixture provided a viscous oil which was dissolved in 5 mL of CH_2Cl_2. The solution was added dropwise to a cooled (−40 °C) solution of CH_3OH (100 mL), and the precipitated polymer was stirred for 20 min after removing the external cooling. The polymer was collected by filtration, and was washed with CH_3OH (2 × 50 mL) and suck-dried. The wet polymer was dried in a vacuum oven at 45 °C for 6 h to give a white solid **6** (1.3 g,

98% polymer recovery). ^{1}H NMR: δ 7.29−6.30 (bh, Ar-*H*), 5.95−5.70 (bh, C*H*-F), 4.66 (bs, CH_2−OH), 4.51−4.10 (bh, CH_2−CHF), 2.10−0.95 (bh, C*HCH*$_2$). ^{13}C NMR: δ 157.8, 145.0, 133.7, 128.5−126.2, 125.5, 114.6, 91.3 (d), 71.1, 64.6, 46.1−39.9. ^{19}F NMR: δ −181.67, −181.97.

Compound 7. DIPEA (2.2 mL, 13 mmol) was added to a stirred solution of **6** (1.3 g, 1.3 mmol) and acryloyl chloride (0.95 mL, 11.7 mmol) in anhydrous CH_2Cl_2 (50 mL) at 0 °C. The solution was stirred overnight at room temperature. The reaction mixture was concentrated to a volume of 5 mL, and the polymer-bound compound **7** was obtained as an off-white solid (1.3 g, 95% polymer recovery) utilizing the standard workup procedure as described for **6**. ^{1}H NMR: δ 7.26−6.20 (bh, Ar-*H*), 6.05 (bt, C*H*═CH_2), 5.73 (bh, C*H*-F, CH═CH_2), 5.08 (bs, CH_2OCO), 4.25−3.95 (bh, CH_2−CHF), 1.95−0.80 (bh, C*HCH*$_2$). ^{13}C NMR: δ 165.9 (*C*═O), 158.3, 145.0, 133.4, 130.9 (CH═CH_2), 130.0, 128.5−127.5, 125.5, 114.6, 91.2 (d), 71.0 (d), 65.9, 43.6−40.3, 40.2. ^{19}F NMR: δ −181.66, −182.06.

Compound 8. To a stirred solution of polymer **7** (1.3 g, 1.3 mmol) and NMO·H_2O (0.44 g, 3.25 mmol) in THF/acetone/H_2O (6:2:1, 50 mL), was added OsO_4 (5% in toluene, 0.26 mL, 0.05 mmol). The reaction mixture was stirred at room temperature for 24 h. The organic solvents were evaporated, and the residue was dissolved in CH_2Cl_2 (75 mL). The solution was washed successively with aq 10% Na_2SO_3, water, and brine. Polymer-bound compound **8** was obtained as an off-white solid (1.3 g, 96%) following the procedure as described in the earlier experiments. ^{1}H NMR: δ 7.30−6.26 (bh, Ar-*H*), 5.75−5.50 (bh, C*H*-F), 5.07 (bs, CH_2OCO), 4.18 (bs, C*H*OH), 4.12−3.85 (bh, CH_2−CHF), 3.76 (bs, CH_2OH), 1.85−0.76 (bh, C*HCH*$_2$). ^{13}C NMR: δ 172.8 (*C*═O), 158.5, 145.1, 132.8, 130.2, 128.4−126.4, 125.6, 114.7, 91.2 (d), 71.7 (*C*HOH), 71.3, 67.3, 63.9 (*C*H_2-OH), 43.8−40.3, 40.2. ^{19}F NMR: δ −182.0.

1-Bromo-4-(2-bromo-1,1-difluoro-ethyl)-benzene 13. Diethylaminosulfur trifluoride (1.45 mL, 10.8 mmol) and *p*-bromophenacyl bromide **1** (2.5 g, 9 mmol) were mixed neat and stirred for 8 ds at room temperature. The reaction mixture was partitioned (CH_2Cl_2/10% Na_2CO_3, 2:1, 100 mL) and the aqueous layer was extracted with CH_2Cl_2. The combined organic phase was washed with water and brine. Removal of solvent provided an orange oil which, on purification by flash chromatography (EtOAc/PetEther, 3:97→10:90), gave a pale yellow solid **13** (1.78 g, 66%). MP = 110−112 °C. R_f = 0.63 (PetEther/EtOAc, 4:1). ^{1}H NMR: δ 7.59 (d, J = 8.4, 2H), 7.38 (d, J = 8.4, 2H), 3.70 (t, $^3J_{HF}$ = 13.5, 2H). ^{13}C NMR: δ 133.0 (t, $^2J_{CF}$ = 27.3), 131.8, 127.0 (t, $^3J_{CF}$ = 5.6), 125.1, 115.9 (t, $^1J_{CF}$ = 244.1), 32.9 (t, $^2J_{CF}$ = 35.3). ^{19}F NMR: δ −97.63. HRMS (EI): calcd for $C_8H_6F_2Br$ (M^+), 297.8804: found, 297.8809.

{4-[2-(4-Bromo-phenyl)-2,2-difluoro-ethoxy]-phenyl}-methanol 14. Sodium hydride (60%, 0.27 g, 6.8 mmol) was added to a solution of 4-hydroxybenzyl alcohol (1.4 g, 11.3 mmol) in anhydrous DMF (75 mL) at room temperature. The suspension was stirred for 30 min, and **13** (1.7 g, 5.6 mmol) was added as a solution in 5 mL of DMF. The reaction mixture was heated to 70 °C and stirred at this temperature for 12 h, after which it was cooled to room temperature. The reaction mixture was partitioned (EtOAc/H_2O, 1:2, 150 mL), and the water layer was extracted with EtOAc (2 × 50 mL). The combined organic phase was washed with water and brine. Solvent was evaporated to afford a yellow oil which was purified by flash chromatography (EtOAc/PetEther, 1:6→1:3) to provide the compound **14** as a pale yellow oil (0.86 g, 45%). R_f = 0.37 (PetEther/EtOAc, 2:1). ^{1}H NMR: δ 7.59 (d, J = 8.4, 2H), 7.45 (d, J = 8.4, 2H), 7.27 (d, J = 8.6, 2H), 6.85 (d, J = 8.6, 2H), 4.62 (s, 2H),4.32 (t, $^3J_{HF}$ = 11.7, 2H). ^{13}C NMR: δ 157.3, 134.4, 133.4 (t, $^2J_{CF}$ = 25.7), 131.7, 128.6, 127.4 (t, $^3J_{CF}$ = 5.7), 124.8, 116.8 (t, $^1J_{CF}$ = 244.1), 114.8, 69.8 (t, $^2J_{CF}$ = 35.2) 64.8. ^{19}F NMR: δ −103.77. HRMS (EI): calcd for $C_{15}H_{13}O_2F_2Br$ (M^+), 342.0067: found, 342.0036.

{4-[2-(4-Bromo-phenyl)-2,2-difluoro-ethoxy]-benzyloxy}-*tert*-butyl-dimethyl-silane. Imidazole (0.24 g, 3.5 mmol) and *tert*-butyldimethylsilyl chloride (0.38 g, 2.5 mmol) were reacted with **14** (0.8 g, 2.3 mmol) following the reaction and workup procedures as described for **2**. The silyl ether (1 g, 94%) was obtained as a clear oil. R_f = 0.67 (PetEther/EtOAc, 3:1). ^{1}H NMR: δ 7.59 (d, J = 8.4, 2H), 7.46 (d, J = 8.4, 2H), 7.23 (d, J = 8.6, 2H), 6.83 (d, J = 8.6, 2H), 4.68 (s, 2H),4.32 (t, $^3J_{HF}$ = 11.9, 2H), 0.94 (s, 9H), 0.09 (s, 6H). ^{13}C NMR: δ 156.8, 134.9, 133.3 (t, $^2J_{CF}$ = 25.7), 131.6, 127.5, 127.4, 127.3 (t, $^3J_{CF}$ = 6.4), 124.8, 116.8 (t, $^1J_{CF}$ = 244.1), 114.5, 69.8 (t, $^2J_{CF}$ = 34.5) 64.5, 25.9, 18.3, −5.2. ^{19}F NMR: δ −103.83. HRMS (EI): calcd for $C_{21}H_{27}O_2F_2BrSi$ (M^+), 456.0931: found, 456.0899.

***tert*-Butyl-{4-[2,2-difluoro-2-(4-vinyl-phenyl)-ethoxy]-benzyloxy}-dimethyl-silane 15.** Tributylvinyl stannane (1.7 mL, 5.9 mmol) was reacted with the product of the earlier experiment (0.9 g, 1.9 mmol) in the presence of $(PPh_3)_4Pd$ (0.22 g, 0.19 mmol), utilizing the procedure described for **4**. The styrene **15** (0.72 g, 91%) was obtained as a clear oil. R_f = 0.67 (PetEther/EtOAc, 4:1). ^{1}H NMR: δ 7.55 (d, J = 8.4, 2H), 7.48 (d, J = 8.4, 2H), 7.23 (d, J = 8.4, 2H), 6.85 (d, J = 8.4, 2H), 6.72 (dd, J = 17.5, 10.9, 1H), 5.81 d, J = 17.5, 1H), 5.34 (d, J = 10.9, 1H), 4.68 (s, 2H),4.34 (t, $^3J_{HF}$ = 12.2, 2H), 0.94 (s, 9H), 0.09 (s, 6H). ^{13}C NMR: δ 157.0, 139.5, 135.9, 134.8, 133.5 (t, $^2J_{CF}$ = 25.7), 127.4, 126.1, 125.8 (t, $^3J_{CF}$ = 6.4), 117.1 (t, $^1J_{CF}$ = 244.1), 115.5, 114.6, 70.0 (t, $^2J_{CF}$ = 34.5) 64.5, 25.9, 18.3, −5.2. ^{19}F NMR: δ −103.83. HRMS (EI): calcd for $C_{23}H_{30}O_2F_2Si$ (M^+), 404.1983; found, 404.1949.

Radical Co-Polymerization of 15 with Styrene. Polymerization of **15** (0.7 g, 1.7 mmol) with styrene (1.8 mL, 15.6 mmol) in the presence of AIBN (0.014 g, 0.08 mmol) was conducted following the procedure as described for **5**, and the soluble polystyrene **16** was obtained as a solid (0.74 g, 32%). Loading capacity was determined by ^{1}H NMR analysis and a value of 0.5 mmol/g was obtained. ^{1}H NMR: δ 7.26−6.35 (bh, Ar-*H*), 4.68 (bs, CH_2OTBS), 4.38−4.22 (bh, CH_2CF$_2$), 1.98−1.02 (C*HCH*$_2$), 0.94 (bs, C*Me*$_3$), 0.10 (bs, Si*Me*$_2$). ^{19}F NMR: δ −103.65.

Cross-Linked Polystyrene 16a. Monomer **15** (1.3 g, 3.2 mmol) was co-polymerized with styrene (1 g, 9.6 mmol) and divinyl benzene (50%, 0.068 g, 0.26 mmol) following the procedure described for **5a**. The polymer was obtained as a solid (1 g). ^{19}F NMR (gel phase in $CDCl_3$): δ −103.44.

Compound 17. Polymer **16** (0.7 g, 0.35 mmol) was treated with Bu_4NF (1 M in THF, 1.75 mL, 1.75 mmol) as per the procedure described for **6**. The de-*O*-silylated polymer-bound compound **17** was obtained as a solid (0.65 g, 98%). ^1H NMR: δ 7.27−6.45 (bh, Ar-*H*), 4.63 (bs, C*H*$_2$OH), 4.34 (bh, C*H*$_2$CF$_2$), 2.20−0.98 (C*H*C*H*$_2$). ^{13}C NMR: δ 157.6, 145.2, 142.3, 134.2, 128.5−125.5, 114.9, 64.7, 45.7−39.9. ^{19}F NMR: δ −103.62.

Compound 17a. Polymer **16a** (1 g) was treated with TBAF (1M, 2 mL) as described above. Polymer was filtered and washed with THF and methanol. Product-bound polymer was dried at 60 °C under vacuum for 8 h to give a solid (0.95 g). ^{19}F NMR (gel phase): δ −103.41.

Compound 18. Following the procedure described for **7**, polymer-bound compound **17** (0.65 g, 0.32 mmol) and acryloyl chloride (0.23 mL, 2.9 mmol) were reacted in the presence of DIPEA (0.55 mL, 3.2 mmol). The anchored compound **18** was obtained as an off-white solid (0.65 g, 97%). ^1H NMR: δ 7.35−6.35 (bh, Ar-*H*), 6.14 (bt, C*H*═CH$_2$), 5.84 (bd, CH═C*H*$_2$), 5.17 (bs, C*H*$_2$OCO), 4.33 (bh, C*H*$_2$CF$_2$), 2.10−0.93 (C*H*C*H*$_2$). ^{13}C NMR: δ 166.0 (*C*═O), 158.0, 145.0, 142.3, 134.4, 131.0 (CH═*C*H$_2$), 130.0, 128.3−127.2, 125.6, 114.8, 70.2 (t), 65.9, 45.9−40.1. ^{19}F NMR: δ −103.62.

Compound 18a. Reaction on polymer **17a** (0.2 g) with acryloyl chloride (0.372 mL) and DIPEA (0.86 mL) was performed as described for **18** and workup as described for **17a** gave a solid polymer (0.2 g). ^{19}F NMR (gel phase): δ −103.37.

Compound 20. Polymer-bound acrylate **18** (0.65 g, 0.325 mmol) was treated with NMO·H$_2$O (0.11 g, 0.82 mmol) and OsO_4 (5% in toluene, 0.065 mL, 0.013 mmol). Standard workup methods gave the glycerate on polymer **20** as a solid (0.62 g, 93%). ^1H NMR: δ 7.32−6.31 (bh, Ar-*H*), 5.21 (bs, C*H*$_2$OCO), 4.29 (bh, C*H*$_2$CF$_2$, C*H*OH), 3.87 (bs, C*H*$_2$OH), 2.15−0.92 (C*H*C*H*$_2$). ^{13}C NMR: δ 172.8, 158.2, 145.0, 142.3, 130.2, 128.8−127.2, 125.6, 114.9, 71.5, 69.8 (t), 67.3, 63.9, 45.4−40.1. ^{19}F NMR: δ −103.63.

Compound 22. NCPS (5 g, 4.5 mmol) and 2,3,5,6-tetrafluoro-4-hydroxybenzyl alcohol **21** (2.5 g, 12.5 mmol) were dissolved in dry DMF (100 mL), followed by the addition of anhydrous K_2CO_3 (1.03 g, 7.5 mmol). The reaction mixture was heated to 65 °C and stirred at this temperature for 12 h. After cooling to room temperature, the reaction mixture was partitioned between CH_2Cl_2 and H_2O (3:1, 250 mL). The water layer was extracted with CH_2Cl_2 (3 × 50 mL) and the combined organic phase was washed with water and brine. Removal of solvent provided a crude solid, which on standard protocol gave dry off-white solid **22** (5.5 g, 95%). ^1H NMR: δ 7.24−6.32 (bh, Ar-*H*), 5.11 (bs, Ar−C*H*$_2$O), 4.71 (bs, C*H*$_2$OH), 2.01−1.32 (C*H*C*H*$_2$). ^{13}C NMR: δ 146.5, 145.2, 144.0, 142.4, 140.0, 137.1, 132.7, 127.9−125.6, 112.2, 77.2, 52.5, 43.6−40.2, 27.85. ^{19}F NMR: δ −146.46, −156.44.

Compound 23. Acryloyl chloride (3.3 mL, 40.5 mmol) was treated with the polymer **22** (5 g, 4.5 mmol) in the presence of DIPEA (7.6 mL, 45 mmol) following the procedure described for **7**. The standard workup and precipitation procedures afforded the ploymer-bound acrylate **23** as off-white solid (5 g, 96%). ^1H NMR: δ 7.27−6.42 (bh, Ar-*H*), 6.17 (bt, C*H*═CH$_2$), 5.89 (bd, CH═C*H*$_2$), 5.29 (bs, C*H*$_2$OCO), 5.18 (bs, Ar−C*H*$_2$O), 1.87−1.32 (C*H*C*H*$_2$). ^{13}C NMR: δ 165.5, 146.9, 145.2, 142.4, 139.9, 138.0, 132.7, 132.5, 127.9−125.6, 107.7, 77.2, 53.5, 46.2−41.9. ^{19}F NMR: δ −144.15, −156.38.

Compound 24. Mukaiayama's method was followed with excess reagent quantities.[18] Acrylate-bound polymer **23** (1 g, 0.9 mmol) was dissolved with phenyl isocyanate (0.85 g, 7.2 mmol) in anhydrous toluene (10 mL) and stirred at room temperature. To this stirred solution was added a mixture of 1-nitropropane (0.32 g, 3.6 mmol) and triethylamine (0.1 mL) in anhydrous toluene (5 mL). The resulting mixture was stirred at room temperature for 2 h and at 80 °C for 6 h. The reaction mixture was precipitated to remove urea, and the filtrate was concentrated to reduce the volume to 4 mL. Precipitation of polymer by usual method afforded a pale yellow solid **24** (1.04 g, 98%). ^1H NMR: δ 7.26−6.42 (bh, Ar−H), 5.29 (bs, C*H*$_2$OCO), 5.16 (bs, Ar−C*H*$_2$O), 5.00 (bs, C*H*CO), 3.22 (bs, C*H*$_2$CHCO), 2.41 (bs, C*H*$_2$CH$_3$), 2.02−0.91 (CHCH$_2$). ^{13}C NMR: δ 169.8, 159.2, 146.9, 145.1, 144.4, 142.2, 139.7, 132.5, 128.8−125.5, 106.9, 76.4, 54.5, 46.2−40.9, 40.7, 40.1, 20.7, 10.6. ^{19}F NMR: δ −143.99, −156.20.

Compound 25. The polymer-bound acrylate **23** (1 g, 0.9 mmol) was reacted with OsO_4 (5% solution, 0.19 mL, 0.036 mmol) and NMO·H$_2$O (0.3 g, 2.3 mmol) following the procedure as described for **8**. Using the same workup and precipitation protocols afforded the anchored glycerate **25** (0.96 g, 93%). ^1H NMR: δ 7.27−6.32 (bh, Ar-*H*), 5.32−5.14 (bh, C*H*$_2$OCO, Ar−C*H*$_2$O), 4.25 (bs, C*H*OH), 3.84 (bs, C*H*$_2$OH), 1.87−1.32 (C*H*C*H*$_2$). ^{13}C NMR: δ 172.3, 147.0, 145.2, 142.4, 139.7, 138.3, 132.5, 127.9−125.6, 106.8, 77.2, 71.5, 63.8, 54.7, 46.2−40.3. ^{19}F NMR: δ −144.03, −156.08.

Compound 26. A literature method was followed to prepare the dioxolane nucleoside intermediate (with toluene as solvent).[19] To a solution of **25** (0.95 g, 0.85 mmol) in toluene (20 mL), was added *p*-toluenesulfonic acid (5 mg) and benzyloxyactaldehyde diethyl acetal (0.477 g, 2.13 mmol). The resulting solution was stirred at 70 °C for 12 h. The reaction was cooled to room temperature and concentrated to give a crude oil which on precipitation and drying provided a solid polymer-bound compound **26** (0.95 g, 95%). ^1H NMR: δ 7.33−6.32 (bh, Ar-*H*), 5.32−5.08 (bh, C*H*$_2$-OCO, Ar−C*H*$_2$O, C*H*O$_2$), 4.70−3.40 (bs, C*H*O, C*H*$_2$O, PhC*H*$_2$OC*H*$_2$), 2.01−0.87 (C*H*C*H*$_2$). ^{13}C NMR: δ 171.6, 171.5, 146.9, 145.2, 144.5, 142.3, 139.9, 138.6, 138.4, 132.5, 128.5−125.4, 106.8, 102.7, 101.4, 77.2, 75.2, 73.5, 73.4, 73.3, 71.0, 70.8, 70.5, 69.5, 63.8, 62.7, 62.6, 54.3, 45.6−40.2. ^{19}F NMR: δ −143.91, −156.23.

Compound 27. Acrylate on polymer **23** (1 g, 0.9 mmol) was dissolved in anhydrous toluene, and freshly distilled cyclopentadiene (0.6 g, 9 mmol) was added. The resulting mixture was heated to 120 °C and stirred at this temperature for 6 h, then cooled to room temperature, and the solvent was evaporated. The crude oily mass thus obtained was poured as a solution in CH_2Cl_2 (4 mL) into cold methanol to precipitate the polymer. Polymer was filtered, washed with pentane, and dried in a vacuum to give an off-white solid

27 (1 g, 93%). ^{1}H NMR: δ 7.22−6.26 (Ar−H), 6.18, 6.10, 6.05, 5.88, 5.18−5.06, 3.16, 3.02, 2.99−2.84, 2.02−0.79 (C*H*C*H*$_2$). ^{13}C NMR: δ 175.6, 174.1, 146.9, 145.1, 144.4, 142.4, 139.9, 138.1, 137.9, 135.5, 132.0, 131.8, 127.6−125.6, 108.1, 77.2, 53.6, 53.4, 49.5, 46.2, 46.0, 45.7, 44.4, 43.0, 42.8, 42.5, 41.6, 40.2, 30.3, 29.1. ^{19}F NMR: δ −144.31, −156.38.

Compound 28. The polymer **24** (1 g, 0.9 mmol) was treated with $NaOCH_3$ (5 mg) in THF/CH_3OH (5:1, 10 mL) at room temperature for 3 h. Solvent was evaporated and the residue was partitioned between CH_2Cl_2/aq NH_4Cl (3:1, 50 mL). The aqueous layer was extracted with CH_2Cl_2 and the combined organic phase was washed with water and brine. Solvent was removed and the polymer was precipitated in cold methanol. The polymer was the same as compound **22** (0.85 g). The filtrate was concentrated, and the residue obtained was purified by flash column chromatography (EtOAc/PetEther, 1:9→1.5:8.5) to give **28** (0.07 g, 55%). ^{1}H NMR: δ 4.95 (t, J = 8.4 Hz, 1H), 3.72 (s, 3H), 3.18 (d, J = 9.1 Hz, 2H), 2.36 (q, J = 7.6 Hz, 2H), 1.13 (t, J = 7.6 Hz, 3H). ^{13}C NMR: δ 171.0, 159.4, 76.8, 52.6, 40.7, 20.8, 10.7.

Compound 29. The dioxolane on polymer **26** (0.95 g, 0.85 mmol) was stirred with $NaOCH_3$ (5 mg) in THF/CH_3OH (5:1, 10 mL) at room temperature for 3 h. The workup procedure as described for compound **28** was followed to get the polymer **22** (0.80 g) and pure compound as an inseparable mixture (1:1) of diastereomeric dioxolanes **29** (0.08 g, 40%). ^{1}H NMR: δ 7.33 (m, 5H), 5.33 (t, J = 3.5 Hz, 0.5H), 5.22 (t, J = 4.0 Hz, 0.5H), 4.68 (m, 3H), 4.32 (t, J = 7.6 Hz, 0.5H), 4.26 (dd, J = 3.8, 8.6 Hz, 0.5H), 4.12 (t, J = 8.1 Hz, 0.5H), 4.00 (dd, J = 5.3, 8.4 Hz, 0.5H), 3.77 (s, 1.5 H), 3.74 (s, 1.5H), 3.71 (m, 2H). ^{13}C NMR: δ 171.2, 170.9, 137.7, 137.6, 128.4, 128.3, 128.2, 127.7, 127.6, 126.8, 104.6, 104.1, 73.8, 73.7, 73.6, 73.5, 70.6, 70.0, 68.5, 68.1, 52.3.

Compound 30. The polymer **27** (1 g) was treated with $NaOCH_3$ (5 mg) in THF/CH_3OH (5:1, 10 mL) at room temperature for 3 h. The standard procedure as described for compound **24** was followed to get the polymer (0.9 g) and compound **30** as an inseparable mixture of isomers (*endo/exo*, 2.3:1, 0.05 g, 35%). ^{1}H NMR: δ 6.20 (m, 2H), 3.69 (s, 1.2H), 3.62 (s, 2.8H), 3.20−2.90 (m, 3H), 2.23−1.28 (m, 4H). ^{13}C NMR: δ 176.7, 175.2, 138.0, 137.7, 135.6, 132.3, 51.6, 51.4, 49.5, 46.5, 46.2, 45.5, 43.0, 42.8, 42.4, 41.5, 30.2, 29.1.

General Experimental Procedure for the Membrane Filtrations. Conditioning of Membrane. Polyaramide membrane was cut to fit the filtration cell (diam. 47 mm) and immersed in distilled water (25 mL) for 1 h with the smooth side of the polymer facing down. The water was decanted, and washing was repeated three times after soaking the membrane for 30 min in distilled water. The washing process was then repeated with absolute ethanol (3 × 25 mL) and toluene (2 × 25 mL). The membrane was stored in toluene to keep it wet.

Ultrafiltration of the Reaction Mixture to Purify the Polymer. The membrane was placed with its smooth surface facing up, and the filtration cell was tightened to avoid any pressure leak. The reaction mixture was washed to remove any acidic or basic reagents, dried over $MgSO_4$, and loaded into the cell. The cell was then tightly closed. Filtration was started by an argon pressure (3 bar) and filtrate was collected. The pressure was released when 4−5 mL of solution was left, and the cell was again charged with 20 mL of washing solvent and closed. Filtration was continued and a second fraction was collected. The process of washing by filtration was repeated two more times and the polymer was pipetted out of the cell. The filtration cell was washed with CH_2Cl_2 and siphoned off. The solvent was evaporated to obtain the pure polymer which was used in the next reaction as such.

In the case of cleavage reaction, the filtrate fractions were concentrated and the residues were analyzed by ^{1}H and ^{13}C NMR. Most of the compound was present in the first two fractions and was found to be pure as confirmed by NMR analysis.

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Supporting Information Available. ^{19}F NMR spectra are available for compounds **21**−**27**. This material is available free of charge via the Internet at http://pubs.acs.org.

References and Notes

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