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The Polymer-Supported Cadiot-Chodkiewicz Coupling of Acetylenes to Produce Unsymmetrical Diynes

John M. Montierth, Dierdre R. DeMario, Mark J. Kurth*, and Neil E. Schore*

Department of Chemistry, University of California, Davis, California 95616, U. S. A.

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Abstract: Cu(II)-catalyzed coupling of polymer-bound ω-haloalkyn-1-ols to terminal alkynes proceeds in moderate yield to give unsymmetrical diynes upon hydrolytic removal from the polymer. Formation of the symmetrical homocoupled byproduct is suppressed relative to conventional Cadiot-Chodkiewicz conditions in homogeneous solution. © 1998 Elsevier Science Ltd. All rights reserved.

INTRODUCTION

Conjugated diynes and polyynes are of interest because of their occurrence in a number of naturally-occurring substances with antibacterial, antifungal, and other biological activity,[1] and their utility in the preparation of novel molecules with very high carbon content.[2] Although the direct coupling of two acetylenes is suitable for the preparation of symmetrical diynes, the synthesis of unsymmetrical systems requires different approaches to inhibit the formation of symmetrical byproducts. In natural product synthesis, for example, unsymmetrical diynes are frequently constructed linearly, building up a terminal diyne from a terminal alkyne, before linkage of the former to another structural unit.[3] Other alternatives include transition-metal based processes that couple alkynes to dihaloalkenes, whereupon subsequent dehydrohalogenation affords an unsymmetrical diyne.[4] The Cadiot-Chodkiewicz reaction provides a valuable solution to this problem in the coupling of a terminal alkyne with a 1-haloacetylene in the presence of a Cu(I) catalyst (eq 1).[5]

$$\mathrm{R{-}C{\equiv}C{-}X} \;+\; \mathrm{H{-}C{\equiv}C{-}R'} \xrightarrow[-\mathrm{HX}]{\mathrm{Cu\,(I)}} \mathrm{R{-}C{\equiv}C{-}C{\equiv}C{-}R'} \qquad (1)$$

This method has been used for the synthesis of unsymmetrical diynes. It appears to be most successful when R and R' are quite dissimilar, e.g., aryl vs. alkyl or unfunctionalized vs. functionalized.[6] In a sometimes serious side reaction, however, the 1-haloalkyne can also react with the catalyst to form the symmetrical homocoupled product (eq 2). In such cases, yields of the desired unsymmetrical product suffer accordingly. For example, the Cadiot-Chodkiewicz coupling of 2,7-octadiyne and 11-bromo-10-undecynoic acid gives only a

$$2\ \mathrm{R{-}C{\equiv}C{-}X} \;+\; 2\,\mathrm{Cu(I)} \xrightarrow{\mathrm{Cu\,(I)}} \mathrm{R{-}C{\equiv}C{-}C{\equiv}C{-}R} \;+\; 2\,\mathrm{Cu(II)} \;+\; 2\ \mathrm{X}^{-} \qquad (2)$$

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*E-mail: mjkurth@ucdavis.edu and neschore@ucdavis.edu

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38% yield of the unsymmetrical triynoic acid, and comparable processes give yields that are similar or lower.[7] In the Cadiot system hydroxylamine is added to reduce Cu(II) and thereby replenish Cu(I) lost to this process.

In our continuing research into polymer-supported synthetic chemistry, we envisioned a potentially useful application of this methodology to the Cadiot-Chodkiewicz process. Attachment of appropriately ω-functionalized 1-haloalkynes to a suitable polymer support should inhibit their mutual interaction and thus favor the desired coupling with a second, different alkyne in solution. Herein we report results from a series of experiments designed to probe the utility of such strategies in bringing about such chemoselectivity. We chose 2%-crosslinked Merrifield resin as the vehicle for our effort, because we have found it to be effective in affording this type of chemoselectivity control in other situations.[8]

RESULTS AND DISCUSSION

Our general approach was similar to that used in earlier studies of polymer attachment effects on chemoselectivity in Pauson-Khand co-cycloaddition reactions.[8a,f] Both bromo- and iodoalkynes were utilized, the former prepared by the method of Strauss,[9] the latter by iodination of the lithium acetylide (eq 3, 4).

$$\mathrm{R{-}C{\equiv}C{-}H} \xrightarrow{\mathrm{Br_2,\ KOH,\ H_2O,\ 0°C}} \mathrm{R{-}C{\equiv}C{-}Br} \qquad (3)$$

$$\mathrm{R{-}C{\equiv}C{-}H} \xrightarrow[\mathrm{2.\ I_2,\ Et_2O,\ -78°C}]{\mathrm{1.\ BuLi,\ Et_2O,\ -78°C}} \mathrm{R{-}C{\equiv}C{-}I} \qquad (4)$$

In order to evaluate the applicability of polymer-support methodology to this problem, we first examined the reactions of a series of haloalkyne substrates under the usual solution-phase Cadiot-Chodkiewicz conditions (eq 5). As summarized in by entries 1, 3, and 5 in Table 1, we found that three- and four-carbon alkynols (i.e., n = 1, 2) performed extremely well in coupling with 1-octyne, affording >90% yields of unsymmetrical diynol with near-total chemoselectivity. In contrast, when n = 3 or 4, approximately one third of the isolated product was the symmetrical diynediol derived from the starting haloalkynol (entries 7, 9, and 11).

$$\mathrm{HO(CH_2)_{\mathit{n}}C{\equiv}C\,X} \xrightarrow{\substack{\text{1-Octyne, CuCl,}\\ \mathrm{NH_2OH{\bullet}HCl,\ 95\%}\\ \mathrm{EtOH,}\ \mathit{n}\text{-}\mathrm{PrNH_2}}} \mathrm{HO(CH_2)_{\mathit{n}}C{\equiv}C{-}C{\equiv}C(CH_2)_5CH_3} + \mathrm{HO(CH_2)_{\mathit{n}}C{\equiv}C{-}C{\equiv}C(CH_2)_{\mathit{n}}{-}OH} \qquad (5)$$

Next, we followed procedures used previously in our laboratories to attach these substrates to and remove reaction products from a functionalized polymer support, as outlined in Scheme 1 (® = polymer backbone).[8]

Scheme 1

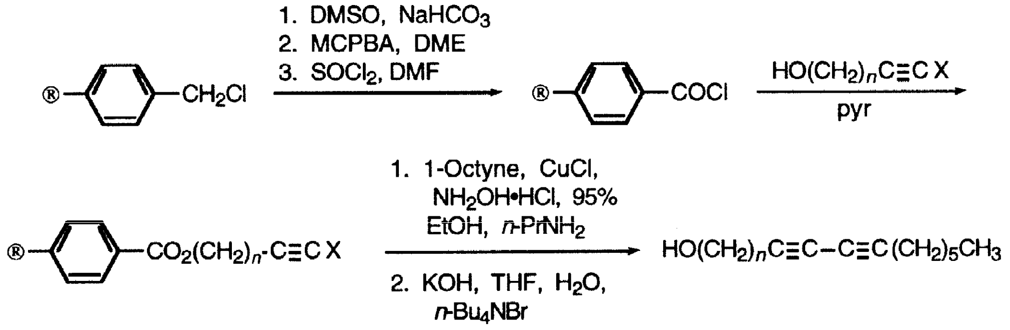
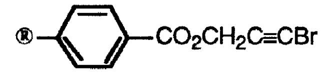
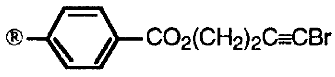
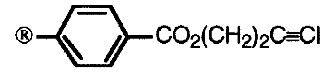
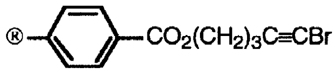
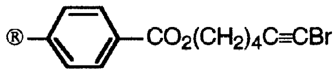
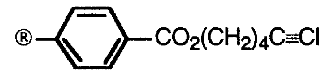


Table 1
Cadiot-Chodkiewicz Coupling Yields for Polymer-Bound *vs.* Solution-Phase Alkyne Derivatives[a]

Entry	Alkyne (® = 2% crosslinked polystyrene backbone)	Yield of cross-coupled product[b]	Yield of homocoupled product[b]
1.	$HOCH_2C\equiv CBr$	97%	trace
2.		69%	0%
3.	$HO(CH_2)_2C\equiv CBr$	93%	trace
4.		81%	0%
5.	$HO(CH_2)_2C\equiv CI$	95%	trace
6.		84%	0%
7.	$HO(CH_2)_3C\equiv CBr$	66%	34%
8.		71%	0%
9.	$HO(CH_2)_4C\equiv CBr$	37%	15%
10.		34%	0%
11.	$HO(CH_2)_4C\equiv CI$	40%	18%
12.		36%	trace

[a] Upon reaction with 1-octyne in 95% ethanol.

[b] Yields of isolated diynes (after cleavage from polymer for even-numbered entries), uncorrected for recovered starting material.

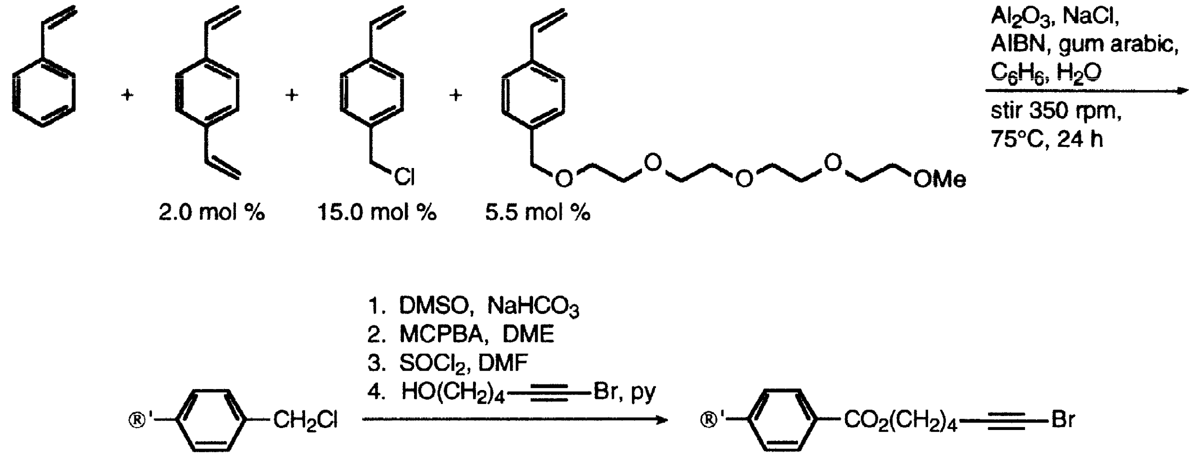
With the solution-phase results for comparison, we proceeded to investigate the polymer-supported counterparts. Initially we prepared polymer-bound 3-butyn-1-ol and attempted its iodination by treatment with LDA followed by I_2. The result of this procedure was formation of the lithium salt of the polymer-bound carboxylic acid, suggesting that elimination of butenyne had occurred. Consequently, we iodinated the alkynol prior to polymer attachment, and successfully obtained the polymer-bound ester with $n = 2$; IR 1718 cm^{-1} (KBr). Upon exposure to the highly polar (95% ethanol) reaction medium associated with the Cadiot-Chodkiewicz process the polymer beads collapsed dramatically in size. Nevertheless, carrying on with the procedure, we were able to isolate an 84% yield of the expected unsymmetrical diynol, accompanied by a mixture of unreacted iodobutynol and butynol from which the halogen had been lost. Thus the chemoselectivity of the coupling process was unaffected by polymer attachment, although the degree of conversion was reduced, suggesting that some polymer-bound iodoalkyne may have been rendered relatively inaccessible to the solution-phase reagents by collapse of the polymer beads. We repeated the polymer-supported procedure in a variety of solvent systems, attempting to find conditions that would be compatible with the chemistry and also permit significant swelling of the polymer matrix. In every case, conversion was lower than in 95% ethanol. Yields in 100% ethanol and in ethanol/THF mixtures were about half those found in 95% ethanol, and no diyne was obtained in solvents such as butanol, or aqueous THF, DMSO, or dimethoxyethane.

Given these observations as general guidelines, we examined the coupling reactions of the remaining haloalkynols, paying particular attention to those for which the solution-phase process was less selective. For example, attempted synthesis of 5,7-tetradecadiyn-1-ol from 1-octyne and either 6-halo-5-hexyn-1-ol ($n = 4$; X = Br or I) in solution gave about a 2.3:1 ratio of hetero- to homocoupled diynes, in ca. 55% yield (Table 1, entries 9 and 11). The progressive worsening of the outcome of the Cadiot process as n in eq 5 increases from 1 to 4 deserves comment. As noted earlier, selectivity for heterocoupled products is best when the groups R and R' in the two alkynes are functionally (e.g., electronically) dissimilar. Thus increasing the spacing between the alkyne and alcohol functions would be expected to reduce selectivity.

On the polymer, again, the beads collapsed upon exposure to the reaction medium, even subsequent to pre-swelling with excess 1-octyne. Nevertheless, using polymer-bound 6-iodo-5-hexyn-1-ol, chemoselectivity in favor of the desired unsymmetrical diyne was virtually 100%: coupling using the standard reagent and solvent mixture followed by hydrolytic removal of all products from the polymer gave a 36% yield of 5,7-tetradecadiyn-1-ol and only traces of the corresponding symmetrical diynediol. In this experiment, unreacted iodoalkynol was not recovered; instead, 5-hexyn-1-ol was obtained, again indicating loss of iodine at some stage of the process. We therefore repeated these experiments with polymer-supported 6-bromo-5-hexyn-1-ol (IR, 1721 cm^{-1}), obtaining unsymmetrical diynol in 34% yield and, in contrast with the outcome using the iodoalkynol, intact unreacted bromoalkynol as the only materials upon hydrolysis. After correction for recovered starting material the yield of diynol was calculated to be 59%, *almost double the best solution-phase results!* As before, attempts to use superior polymer-swelling solvents for the coupling process offered no improvement.

In one final attempt to address the issue of incompatibility of the reaction medium and the polymer, we examined the use of a resin with superior swelling characteristics. We copolymerized styrene, *p*-(chloromethyl)styrene, and *p*-divinylbenzene, with varying proportions of two polyether-functionalized styrene derivatives under standard suspension polymerization conditions. For the purposes of this study we chose to use a 2%-crosslinked polymer derived from a mixture containing 5.5% of the monomer prepared by Williamson ether synthesis between *p*-(chloromethyl)styrene and the alkoxide of tetraethylene glycol monomethyl ether. This polymer was obtained as beads that exhibited roughly double the swelling capacity of ordinary 2%-crosslinked Merrifield's resin in a wide range of solvents. In particular, exposure to 95% ethanol caused nearly a doubling in bead size (absorption of ca. 0.8 mL solvent/g dry bead). Furthermore, the resin proved to be suitable for refunctionalization under conditions essentially identical to those used for Merrifield's polymer itself (Scheme 2).[10] Thus, conversion to the corresponding aroyl chloride formproceeded uneventfully, and estification with 6-bromo-5-hexyn-1-ol gave a polymer suitable for examination under Cadiot conditions. In the event, however, coupling results were considerably worse than those obtainedusing Merrifield's resin itself: upon product cleavage, only a 20% total yield of diynes was obtained, and surprisingly, the majority of the product mixture was the *symmetrical* diynediol derived from the coupling of two polymer-bound bromohexynol moieties. Evidently the increased swelling of this resin leads to a significant increase in chain mobility over that in Merrifield's resin, permitting coupling of polymer-bound substrates to compete successfully over reaction with solution-phase alkyne. Moreover, as the former transformation proceeds, the effective crosslinking of the polymer increases, leading to a cessation of all reaction at relatively low conversion as neither solution-phase reagents nor substrates can penetrate into the interior of the bead.

Scheme 2



Despite this particular negative result, it is still noteworthy that moderate to good yields of diynes can be obtained under conditions where the beads of Merrifield's resin remain in a collapsed state, such that diffusion of solution phase reagents into the interior of the bead is at least somewhat inhibited. It is also worth noting that the chemistry succeeds in spite of the requirement for a (presumably rather insoluble) alkynylcopper species to couple with a polymer-bound haloalkyne, which is itself in the solid state. Most importantly for practical purposes, the polymer-supported version of the reaction affords *effective* site isolation to the extent necessary to completely suppress the formation of symmetrical coupling product, while providing yields of the desired cross-coupled product comparable to those obtained in solution.[11] Reduced conversion on the polymer is the trade-off that prevents yields from being higher, based on the return of unconsumed haloalkyne in these systems. It should be noted that yield calculations for the polymer-supported reactions have been based on the nominal degree of functionality of 1 meq/gram of original Merrifield's resin, which after correction for the added mass of the haloalkynol moiety translates into ca. 0.85–0.9 meq substrate functionality per gram of resin. It is likely that the actual available functionality is somewhat lower.[cf. ref. 8f] As a result the yields reported in Table 1 are most likely conservative estimates, which may be low by as much as 10%. These results suggest that the solvent-polymer incompatibility issue is less of a problem than we had anticipated it would be. This notion is consistent with the realization that 50% of the volume of a spherical polymer bead is contained in the outer 20% of the radius, and nearly 90% of the volume in the outer 50%. Clearly solvent and reagent penetration is sufficient even in collapsed beads to reach most of the functionalized sites.

EXPERIMENTAL SECTION

General. General procedures associated with polymer-supported synthesis, including the preparation of polymer-supported aroyl chloride derived from 2% crosslinked PS-DVB (polystyrene-divinylbenzene) Merrifield's resin (Scheme 1), have been described previously.[8d,f] Flash chromatography utilized SiO_2 with a mobile phase of 40% Et_2O in hexane. ^1H-NMR spectra were recorded at 300 MHz, ^{13}C-NMR at 75 MHz, all in $CDCl_3$ solvent. Literature references are provided for compounds which have been synthesized previously.

4-Iodo-3-butyn-1-ol.[12] To a solution of 1.88 g 3-butyn-1-ol (26.8 mmol) in 80 mL Et_2O at –78°C was added 23 mL 2.33*M* *n*-BuLi (53.5 mmol). The thick suspension was stirred at –78°C for 15 min and then allowed to warm to rt over 2 hr. After this time, the suspension was again cooled to –78°C and to it was added 6.70 g (51.9 mmol) I_2 in 40 mL Et_2O. After warming to rt and standing overnight, the mixture was quenched with H_2O, and the organic layer separated and washed with H_2O and satd aq NaCl (2 x 30 mL), and dried (Na_2SO_4). A yellow oil with a pungent, sweet odor was obtained, that was purified by flash chromatography to yield a yellowish oil (4.94 g, 94% yield). ^{1}H-NMR δ 1.76 (s, 1H), 2.64 (t, J = 6.5 Hz; 2H), 3.73 (t, J = 6.5 Hz; 2H); ^{13}C-NMR δ –4.1, 24.8, 60.7, 91.2; Anal: calcd for C_4H_5IO C, 24.51%; H, 2.57%; I, 64.75%, found C, 24.64%; H, 2.54%; I, 64.82%.

Similarly, 6-iodo-5-hexyn-1-ol[13] was prepared in 90% yield. ^{1}H-NMR δ 1.46 (s, 1H), 1.65 (m, 4H), 2.41 (t, J = 6.6 Hz; 2H), 3.66 (t, J = 6.3 Hz; 2H); ^{13}C-NMR δ –6.7, 20.5, 24.7, 31.5, 62.1, 94.2.

4-Bromo-3-butyn-1-ol. To a solution of 11.49 g KOH in 200 mL H_2O was added 9.3 g Br_2, and the solution cooled to 0°C. The flask was covered with Al foil and then 3.57 g 3-butyn-1-ol (51.7 mmol) was added. The mixture was stirred at 0°C for 3 hr and then extracted with 2 x 50 mL Et_2O. After drying (Na_2SO_4) the solvent was removed to afford a yellow oil, that was purified by flash chromatography to yield a yellowish oil with a pungent, disagreeable odor (5.74 g, 75% yield). ^{1}H-NMR δ 1.74 (s, 1H), 2.49 (t, J = 6.3 Hz; 2H), 3.74 (t, J = 6.3 Hz; 2H); ^{13}C-NMR δ 23.5, 39.5, 60.3, 77.1; Anal: calcd for C_4H_5BrO C, 32.25%; H, 3.38%; Br, 53.63%, found C, 32.20%; H, 3.32%; Br, 53.58%.

By means of a similar procedure 3-bromo-2-propyn-1-ol[14] was prepared in 96% yield. ^{1}H-NMR δ 1.82 (s, 1H), 4.30 (s, 2H); ^{13}C-NMR δ 45.4, 51.1, 78.0.

Similarly, 5-bromo-4-pentyn-1-ol[15] was prepared in 90% yield. ^{1}H-NMR δ 1.61 (s, 1H), 1.76 (quin, J = 6.6 Hz; 2H), 2.34 (t, J = 7.2 Hz; 2H), 3.74 (t, J = 6.3 Hz; 2H); ^{13}C-NMR δ 16.0, 30.7, 38.1, 60.8, 79.4.

Similarly, 6-bromo-5-hexyn-1-ol[16] was prepared in 98% yield. ^{1}H-NMR δ 1.33 (s, 1H), 1.62 (m, 4H), 2.26 (t, J = 6.6 Hz; 2H), 3.67 (t, J = 6.0 Hz; 2H); ^{13}C-NMR δ 19.3, 24.5, 31.5, 62.0, 68.4, 79.9.

3,5-Dodecadiyn-1-ol.[17] Cadiot-Chodkiewicz Reaction under Solution-Phase Conditions. To a solution of 0.112 g 1-octyne (1.02 mmol) in 5 mL 95% EtOH was added 54 mg NH_2OH, 10 mg CuCl, and 0.15 mL *n*-propylamine. 4-Iodo-3-butyn-1-ol (0.199 g, 1.02 mmol) was added, and the mixture was stirred at rt under Ar. The initially light yellow solution rapidly changed color, first, to pale green, and then finally to amber. The mixture was extracted with Et_2O and the organic layer washed with H_2O and satd aq NaCl. Filtering and evaporation of the solvent provided a crude oil that was purified by flash chromatography to afford a the product as a colorless oil (0.172 g, 95% yield). ^{1}H-NMR δ 0.85 (t, J = 6.9 Hz; 3H), 1.25 (m, 6H), 1.47 (quintet, J = 7.2 Hz; 2H), 2.21 (t, J = 7.2 Hz; 2H), 2.48 (t, J = 6.3 Hz; 2H), 2.62 (s, 1H), 3.68 (t, J = 6.3 Hz; 2H); ^{13}C-NMR δ 13.9, 19.0, 22.4, 23.4, 28.1, 28.4, 31.2, 60.6, 64.8, 66.9, 73.7, 78.1. A similar preparation beginning with 4-bromo-3-butyn-1-ol afforded **1** in 93% yield.

By means of a similar procedure 2,4-undecadiyne-1-ol[18] was prepared from 3-bromo-2-propyn-1-ol and 1-octene in 97% yield. ^{1}H-NMR δ 0.88 (t, J = 6.9 Hz; 3H), 1.29 (m, 6H), 1.53 (quintet, J = 7.5 Hz; 2H), 1.71 (brs, 1H), 2.27 (t, J = 6.9 Hz; 2H), 4.31 (s, 2H); ^{13}C-NMR δ 14.0, 19.2, 22.5, 28.1, 28.5, 31.2, 51.5, 64.3, 70.9, 73.4, 81.9.

Similarly, 4,6-tridecadiyne-1-ol was prepared from 5-bromo-4-pentyn-1-ol and 1-octene in 66% yield, accompanied by 34% of 4,6-decadiyn-1,10-diol.[19] ^{1}H-NMR δ 0.88 (t, J = 6.9 Hz; 3H), 1.25-1.55 (m, 9H), 1.78 (quintet, J = 6.6 Hz; 2H), 2.24 (t, J = 6.9 Hz; 2H), 2.39 (t, J = 6.9 Hz; 2H), 3.75 (t, J = 6.3 Hz; 2H); ^{13}C-NMR δ 14.0, 15.7, 19.2, 22.5, 28.3, 28.5, 31.0, 31.3, 61.5, 65.0, 65.8, 76.4, 77.9; FT-IR (neat) 2230 (w), 3300 (br) cm^{-1}; HRMS (FAB+): calcd for $C_{13}H_{19}O$ $(M-H)^+$ 191.1360, found 191.1398.

Similarly, 5,7-tetradecadiyne-1-ol[20] was prepared from 6-bromo-5-hexyn-1-ol and 1-octene in 37% yield, accompanied by 15% of 5,7-dodecadiyn-1,12-diol.[21] ^{1}H-NMR δ 0.88 (t, J = 6.9 Hz; 3H), 1.25-1.70 (m, 13H), 2.24 (t, J = 6.9 Hz; 2H), 2.30 (t, J = 6.6 Hz; 2H), 3.66 (t, J = 6.3 Hz; 2H); ^{13}C-NMR δ 14.0, 19.0, 19.1, 22.5, 24.6, 28.3, 28.5, 31.2, 31.7, 62.2, 65.1, 65.7, 76.9, 77.7. A similar preparation beginning with 4-iodo-3-butyn-1-ol gave the same products in 40% and 18% yields, respectively.

General Preparation of 2%-Crosslinked PS-DVB Polymer-bound ω-Haloalkynyl Aroates. 2%-Crosslinked PS-DVB aroyl chloride resin (4.66 g, ca. 4 meq of –COCl functionality[8f]) was mixed with pyridine (35 mL) and a 2–3 fold excess of the respective ω-haloalkyn-1-ol. The suspension was stirred under Ar at rt for 2 days, filtered through a fine porosity frit, and the resin washed with 1:1 pyridine/H_2O (2 x 30 mL), H_2O (2 x 30 mL), 95% EtOH (2 x 30 mL), DME (2 x 30 mL), and Et_2O (2 x 30 mL). After drying for 2 days in vacuo at rt, a light brown powdery resin was typically recovered: FTIR 1720 cm^{-1}.

General Procedure for Cadiot-Chodkiewicz Reaction under Polymer-Supported Conditions. To 1.0 g 2%-crosslinked PS-DVB haloalkynyl-esterified resin (ca. 0.9 meq bromoalkynyl or 0.85 meq iodoalkynyl ester functionality, based upon 1 meq of $-CH_2Cl$ residues in the original Merrifield's resin) was added 12 mg CuCl and 33 mg $NH_2OH{\cdot}HCl$ and the vessel purged with N_2. To this solid mixture was added 4 mL 95% EtOH, followed by 0.15 mL *n*-propylamine and finally 0.30 mL 1-octyne. The mixture was stirred for 2 d at rt, filtered, and the polymer washed with EtOH (3 x 20 mL), THF (3 x 20 mL), and Et_2O (4 x 30 mL), and vacuum dried. The material thus obtained exhibited an FTIR spectrum similar to the initial resin, except for the occasional appearance of an absorption at 3300 cm^{-1} from the iodoalkynyl-functionalized starting material. Removal of the product was effected as follows. To a suspension of 0.3 g resin in 15 mL THF was added a solution of 0.85 g KOH in 5 mL water and 20 mg tetra-*n*-butylammonium bromide. The mixture was refluxed for 2 days, after which it was filtered and the resin washed with H_2O (3 x 5 mL) and THF (2 x 5 mL). The combined filtrates were rotary evaporated and the resulting material extracted with Et_2O (2 x 25 mL) and the organic layer dried over Na_2SO_4. After evaporation of the solvent, the crude product (typically a yellow oil) was recovered which was purified by flash chromatography. Yields of purified products, which were spectroscopically indistinguishable from those isolated by solution-phase synthesis, are listed in Table 1.

Preparation of 2%-Crosslinked PS-DVB Aroyl Chloride Copolymer Incorporating 5% Tetraethylene Glycol-Monomethyl Ether-Functionalized Styrene Monomer, and Subsequent Cadiot-Chodkiewicz Reaction. To a mixture of 1.43 g (4.44 mmol) of the mixed *p*-vinylbenzyl methyl ether of tetraethylene glycol, 1.85 g (12.1 mmol) *p*-(chloromethyl)styrene, 0.39 g 55% *p*-divinylbenzene (remainder ethylvinylbenzene; 3.00 mmol total monomer containing 1.65 mmol divinylbenzene), and 6.37 g (61.2 mmol) styrene was added 8.42 g benzene. The resulting solution was washed with 10 mL aq Na_2CO_3 to remove inhibitor. To 80 mL water was added 5.08 g gum arabic, 78 mg Al_2O_3, 17.5 g NaCl, and 0.522 g AIBN. After a 1 hr N_2 purge, 7.81 g of the monomer solution mixture was added and the suspension stirred under N_2 at 350 rpm with a blade stirrer at 75°C for 24 hr. The suspension was then filtered and the polymer washed in turn with 1:1 6M HCl/THF, THF, Et_2O, and finally hexane. The light brown powdery resin thus obtained was subjected to the same transformations under essentially identical conditions as described previously for Merrifield's resin,[8f] producing a resin functionalized as an aroyl chloride. Titration of the resin at the aroic acid stage[8d] indicated a loading of ca. 0.55 meq/g resin.

Esterification of this polymer using 6-bromo-5-hexyn-1-ol followed by Cadiot reaction with 1-octene under the conditions described previously afforded a 5% yield of 5,7-tetradecadiyne-1-ol accompanied by 15% of 5,7-dodecadiyn-1,12-diol.

ACKNOWLEDGMENT

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[10] Full details of the perparations and properties of all of these polymers will be presented elsewhere.

[11] While these results are consistent with others achieved in our laboratories, successful extrapolation to other systems depends upon the kinetic competition between reaction of two polymer-bound functional sites vs. reaction of a polymer-bound moiety and a solution-phase reagent *in the specific system*. Cf. Fyles TM; Leznoff CC *Can. J. Chem.* **1976**, *54*, 935.

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