The Synthesis of (4-Ethenylphenyl)diphenylmethanol

A. Nzeru, J. R. Ebdon, and S. Rimmer*

The Polymer Centre, Lancaster University, Bailrigg, Lancaster, Lancs', UK, LA1 4YA

Received June 26, 1997

Polymer-immobilized trityl alcohol moieties are important protecting groups for solid phase peptide synthesis. We also have an interest in polymers functionalized with this group as precursors to potential stable free radicals in living free-radical polymerization. The preparation of these polymers is normally carried out by lithiation of polystyrene beads followed by quenching of the lithium salt with benzophenone.[1] It would be advantageous, however, to synthesize a functional monomer ((4-ethenylphenyl)diphenylmethanol (**1**)) and then copolymerize this with styrene in a suspension polymerization. The advantage of this method is that it allows more control over the final composition of the product.

We considered that lithiation of halostyrenes should lead to polymerization of any nonlithiated halostyrene. Synthesis of styryl organometallics with protection of the vinyl group as the 2-phenylethyl bromide has been reported for this reason.[2] Grignard reactions have also been used.[3−6] However, the normal procedure in Grignard reactions is to add the alkyl halide to magnesium so that the Grignard reagent has little chance to react with the halostyrene. We were therefore surprised to find a report[7] on the synthesis and polymerization of **1** by addition of *tert*-butyllithium to bromostyrene followed by reaction of the supposed styryllithium with benzophenone. Since this procedure must initially produce styryllithium (an anionic initiator) in the presence of bromostyrene (a monomer that is capable of undergoing anionic polymerization[8]), anionic polymerization should ensue. Therefore we have attempted to repeat this preparation. The product was as reported earlier[7] as a viscous yellow oil. In our hands the material produced from this procedure had a highly viscous nature. Size exclusion chromatography (SEC) analysis of this oil showed it to be polymeric in nature. The SEC chromatogram is shown in Figure 1 (Supporting Information). The number average molecular weight (against polystyrene standards) of the polymeric product was 105 kg mol^{-1} Also shown in this plot is the low molecular weight peak of the unreacted benzophenone. SEC can be used in a semiquantitative manner to assay the fraction of polymer in the oil. Assuming that the refractive index response factors are similar for each component, then the fraction of polymer in the product is approximately 0.5 mol %. The product was also subjected to GC-MS which failed to detect a product that could be assigned to **1**. The main component is benzophenone. Clearly the polymer is a major component of this reaction mixture. The ^{1}H spectrum of the product shows some evidence for the formation of **1**. However, the spectrum also shows strong evidence for the presence of substantial amounts of a polymer based on styryl repeat units. That is in the ^{1}H NMR spectrum (Figure 2, Supporting Information) broad peaks between 6.8 and 7.4 ppm, which are typical of phenyl units pendent from a polystyrene derivative, are observed. The main peaks in the aliphatic region are also broad and can be assigned to the main chain resonances of a carbon polymer chain. Resonances are observed at 5.4 and 5.7 ppm (doublets) which could be assigned to **1** so that some evidence for the production of **1** has been observed but the major product is polymeric.

Anionic polymerization is known not to occur with electron rich alkenes. It therefore occurred to us that styryllithium anion should be sufficiently electron rich to prevent attack on the vinyl group by nucleophilic agents. Therefore, if the preparation could be carried out in such a way that the halostyrene is only present at low concentration and the rate of lithiation is fast, then anionic polymerization should be minimized allowing the styryllithium to be formed without undergoing nucleophilic initiation of an anionic polymerization. A simple way of achieving this would appear to be the reversal of the mode of addition. So that addition of bromosytene to *tert*-butyllithium should give the required result.

Carrying out this procedure in dry diethyl ether solvent gives the desired styryllithium. After the addition of benzophenone, the product was subjected again to SEC analysis. No polymer products were observed, instead a single low molecular weight sharp peak was observed. GC-MS of the product gave one GC peak with the highest weight ion equal to 269 *m*/*z*, which corresponds to the desired product minus OH. No evidence for the presence of benzophenone could be found. NMR analysis of the product also confirmed the expected structure (see Figures 3 and 4, Supporting Information). After purification this product was produced as a white crystalline powder, with a melting point of 54−55 °C. This observation is in conflict with the reported physical form of this material i.e., a viscous oil.[1]

In the previous work no attempt to polymerize the monomer to give an easily characterized linear polymer was made. We considered that the compound **1** might have a tendency to undergo hydrogen abstraction during radical poymerization as shown in Scheme 1. This reaction would effectively terminate polymerization. We therefore polymerized the monomer with styrene under radical conditions (as shown in Scheme 2). This yielded a polymer with a Gaussian distribution of molecular weights (M_n = 13 kg mol^{-1}, M_w/M_n = 1.9). The 5 h reaction period yielded a conversion of approximately 10%. ^{1}H NMR confirmed the presence of both monomer units in the main chain. The spectrum is shown in Figure 5, Supporting Information.

In conclusion we have shown that the reported procedure for the synthesis of **1** produces mainly polymer rather than the target compound. The procedure can be improved by reversing the mode of addition of bromostyrene and *tert*-butyllithium. Thus by adding 4-bromostryene to *tert*-butyllithium it is possible to minimize the rate of nucleophilic attack on the vinyl group of 4-bromostyrene. Future reports will present the copolymer-

---

* To whom correspondence should be addressed. Fax +44 (1524)-844037, e-mail s.rimmer@lancaster.ac.uk

[1] *Functionalized polymers and their applications*; Akelah, A., Moet, A., Eds.; Chapman and Hall: New York, 1990; p 75.

[2] Saunders, J.; Williams, R. A. *J. Am. Chem. Soc.* **1957**, *79*, 3712.

[3] Leebrick, J. R.; Ramsden, H. E. *J. Org. Chem.* **1958**, *23*, 935.

[4] Sewar, A. N.; Wirth, J.; Neville, R. *J. Org. Chem.* **1960**, *25*, 807.

[5] Letsinger, R. L.; Kornet, M. J.; Mahadevan, V.; Jerina, D. M. *J. Am. Chem. Soc.* **1964**, *86*, 5163.

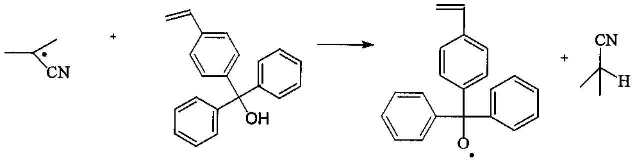
[6] Rabinowitz, R.; Marcus, R. *J. Org. Chem.* **1961**, *26*, 4157.

[7] Borhan, B.; Wilson , J. A.; Gasch, M. J.; Ying, K.; Kurth, D. M.; Kurth, M. J. *J. Org. Chem.* **1995**, *60*, 7375.

[8] Konigsberg, I.; Jagurgrodzinski, J. *J. Polym. Sci. A-Polym. Chem.* **1983**, *21*, 2649.

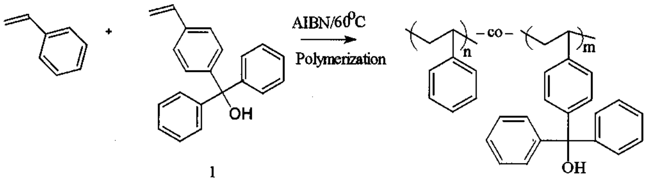
S0022-3263(97)01163-8 CCC: $14.00

Scheme 1. Possible Inhibition Reaction of Compound 1 during Radical Copolymerization



1

Scheme 2. Radical Copolymerization of Compound 1



1

ization reactivity ratios and also procedures for the preparation of gellike and macroreticular polymer supports functionalized with trityl alcohol.

Experimental Section

Analysis. GC-MS was carried out on a Perkin-Elmer 8420 gas chromatograph fitted to a Perkin-Elmer ITD. The column (Alltech (UK)) was 30 m long with an internal diameter of 0.2 mm and a capillary film thickness of 0.25 μm and was a BP1 type coating. The sample was injected from dichloromethane solution at 350 °C. The heating ramp was 50−320 °C at 25 °C min^{-1} with a helium pressure of 10 psi. SEC measurements where carried out with Styragel 5 mm mixed gel columns, calibrated against polystyrene standards, (Polymer Laboratories) and a refractive index detector system. Tetrahydrofuran was used as the eluent at a flow rate of 1.0 cm^3 min^{-1}. Sample concentrations were approximately 0.2 g 100 cm^{-3}. The NMR spectra were recorded at 400 MHz (^{1}H) and 100 MHz (^{13}C); tetramethylsilane was used as the internal standard.

Materials. Diethyl ether was dried by first refluxing in a mixture of a dispersion of sodium in oil and benzophenone. Once the characterstic purple coloration of the dry sodium−benzophenone complex was observed, the dry ether was distilled onto dry 4A molecular sieves and used immediately. THF was SEC grade (Fisher) and used as supplied. Petroleum ether 40−60 (Aldrich) was used as supplied. Toluene (Aldrich) was distilled before use.

Repeat Preparation of (4-ethenylphenyl)diphenylmethanol Using Previously Reported Method. 4-Bromostyrene (20.0 g, 0.105 mol) was dissolved in dry diethyl ether (500 mL). This solution was then cooled under nitrogen to −78 °C. *tert*-Butyllithium (1.7 M, 0.231 mol) was then added. Benzophenone (19.6 g, 0.110 mol) was then dissolved in ether (30 mL) and added dropwise to the reaction mixture. The reaction was then allowed to warm to room temperature and stirred for a further 4 h. The reaction mixture was worked-up by washing with 1% H_2SO_4 and saturated NaCl. The solvent was then removed to yield a highly viscous oil.

Synthesis of (4-Ethenylphenyl)diphenylmethanol (1). *tert*-Butyllithium (1.7 M, 0.0578 mol) was dissolved in dry diethyl ether (125 mL). The solution was cooled to −78 °C and put under nitrogen. 4-Bromostyrene (5.0 g, 0.0263 mol) was then fed dropwise into the vessel with stirring. Transmetalation was instantaneous and gave a red-colored solution of 4-styryllithium. Benzophenone (4.9 g, 0.0275 g) dissolved in dry diethyl ether (7.5 mL) was then added dropwise. On complete addition the cooling bath was removed, and the reaction was allowed to warm to room temperature. After 4 h the reaction was washed with 1% H_2SO_4 (75 mL) and saturated NaCl solution (75 mL). The product was dried with Na_2SO_4 and recrystalized from 40−60 petroleum ether. Yield 60%; M^+(− OH) = 269, FTIR, 3300−3600, 3000−3100, 2000−1800, 1625, 1575, 1550, 1500, 1450, 1400, 1300, 1200, 1150, 1140, 1000, 900, 850, 775, 675, 650 cm^{-1}; ^{1} H NMR (400 MHz, $CDCl_3$) 2.82 (1H), 5.25 (1H, d), 5.77 (1H, d), 6.75 (1H, t), 7.2−7.4 (14H, m). ^{13}C NMR (100 MHz, $CDCl_3$) 81.8, 114, 125.7, 127.2, 127.8, 127.9, 128.1, 136.3, 136.4, 146.4, 146.7. Anal. C 87.8%, H 6.5%, O 5.6% (expected C 88.4%, H 6.3% O 5.6%). Mp = 54−55 °C.

Copolymerization of 1 with Styrene. Distilled styrene (0.4160 g, 4.00 mmol) was mixed with **1** (0.1250 g 0.43 mmol) and toluene (4.5 mL). Azobis(isobutyronitrile) (0.005 g 0.03 mmol) was then added. This solution was then added to an ampule and degassed using the usual freeze/thaw cycling method. Four cycles were performed before the ampule was sealed off. The ampule was placed in a water bath at 60 °C for 5 h. After this time the ampule was opened, and the solution precipitated into methanol. The resultant polymer was isolated, redissolved in toluene, and reprecipitated into methanol.

Supporting Information Available: Figures 1−5 referred to in the text (5 pages). This material is contained in libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.

JO971163H