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An Efficient Synthesis of $^{13}C_{12}$-Benzoyl Peroxide

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SUMMARY

$^{13}C_{12}$-Benzoyl peroxide was prepared in overall yield of 78% from $^{13}C_6$-benzene via acetophenone, benzoic acid and benzoyl chloride intermediates.

Keywords: $^{13}C_6$-benzene, $^{13}C_6$-acetophenone, $^{13}C_6$-benzoic acid, $^{13}C_{12}$-benzoyl peroxide

INTRODUCTION

As part of a continuing study of benzoyl peroxides as initiators for radical polymerizations (1) ^{13}C-labelled benzoyl peroxide was required in order to facilitate our investigation by ^{13}C NMR spectroscopy of the polymers obtained. It is expected, that the approach will throw light on the balance of initiation by benzoyloxy and by phenyl radicals without any perturbation potentially caused by fluorine labels previously used (1).

RESULTS AND DISCUSSION

The usual method of preparation of benzoyl peroxide is from benzoic acid via benzoyl chloride (2). In the present case an approach was sought which was based on the

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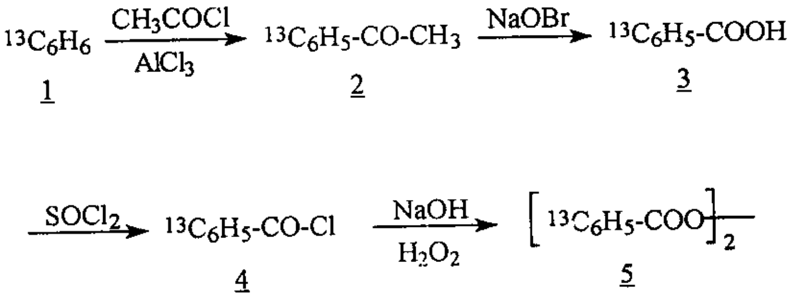
conversion of the commercially available $^{13}C_6$-benzene into benzoic acid with high efficiency (3). The synthetic route chosen is shown in the Scheme.

Scheme



$$\underset{\underline{1}}{{}^{13}C_6H_6} \xrightarrow[AlCl_3]{CH_3COCl} \underset{\underline{2}}{{}^{13}C_6H_5\text{-}CO\text{-}CH_3} \xrightarrow{NaOBr} \underset{\underline{3}}{{}^{13}C_6H_5\text{-}COOH}$$

$$\xrightarrow{SOCl_2} \underset{\underline{4}}{{}^{13}C_6H_5\text{-}CO\text{-}Cl} \xrightarrow[H_2O_2]{NaOH} \underset{\underline{5}}{\left[{}^{13}C_6H_5\text{-}COO\right]_2}$$

Benzene 1 was converted into acetophenone 2 by a modification of the method of Smeets and Verhulst (4) in 94% yield. The conversion into benzoic acid 3 was achieved in 90% yield by using the haloform reaction according to the method developed by Staunton and Eisenbraun (5). The preparation of benzoyl peroxide 5 via benzoyl chloride 4 was accomplished in 93% over the two steps.

EXPERIMENTAL

All chemicals were used as supplied, except that acetyl chloride was redistilled before use. Infrared spectra were recorded on a Nicolet 205 FT-IR spectrometer, ^{1}H-NMR and ^{13}C-NMR spectra were acquired on a JEOL GSX 400 spectrometer and mass spectra were obtained on a Perkin-Elmer TurboMass GC/MS spectrometer using electron impact ionization.

$^{13}C_6$-acetophenone

Aluminium chloride (6.26 g, 0.047 mole) was added to a solution of acetyl chloride (7 ml, ca 0.098 mole) in dichloromethane (12 ml) and the mixture was stirred in a cold water bath. Dried N_2 was blown through the system and $^{13}C_6$-benzene (3.52 g, 0.045 mole) was added slowly. The solid dissolved and HCl gas was evolved. The mixture was stirred in the water bath for an hour (until HCl evolution ceased) and then transferred on to crushed ice (25 g). The aqueous solution was extracted twice with dichloromethane (20 ml), the combined organic layers were washed with dilute NaOH solution, dried with anhydrous $MgSO_4$ and the solvent evaporated in vacuo, leaving 4.96 g of a pale yellow oil, 94% crude yield. Its spectroscopic properties were entirely consistent with the expected structure: IR, $\nu_{C=O}$ 1683cm^{-1}; in capillary GC/MS there was a single component, M^+ - *m/z* 126 , $(M\text{-}CH_3)^+$ - *m/z* 111; ^{1}H-NMR (400 MHz) δ 2.60 (s, 3H, CH_3), δ 7.2-8.5 complex multiplets, Ar-H), ^{13}C-NMR (400 MHz) multiplets centred on δ 128, 133 and 137 were in accord with the expected positions.

$^{13}C_6$-benzoic acid

Crude $^{13}C_6$-acetophenone (4.77 g, 0.0378 mole) was mixed with NaOBr solution (180 ml, excess; prepared according to the method of Staunton and Eisenbraun, ref. 5) and stirred in an icebath for three hours. The excess of NaOBr was destroyed with solid $NaHSO_3$ and the aqueous solution was extracted twice with dichloromethane (30 ml portions), cooled in an ice-bath and acidified with conc. HCl. The separated benzoic acid was extracted with three portions of dichloromethane (30 ml), the organic layers dried with anhydrous $MgSO_4$ and the solvent evaporated in vacuo, producing benzoic acid (4.37 g) in 90% yield. The product, without any further purification, melted at 122-123.5°C. Its spectroscopic properties were entirely consistent with the expected structure: IR, $\nu_{C=O}$ 1686cm^{-1}; in capillary GC/MS there was a single component, M^+ - *m/z* 128 , $(M\text{-}OH)^+$ - *m/z* 111; ^{1}H-NMR (400 MHz) δ 7.2-8.4 complex multiplets, Ar-H), ^{13}C-NMR (400 MHz) multiplets in the range δ 127.7-131 and a triplet with further splitting, centred at δ 133.7, were in accord with the expected positions.

$^{13}C_{12}$-benzoyl peroxide

$^{13}C_6$-benzoic acid (1.42 g, 0.011 mole) was dissolved in benzene (10 ml) and heated under reflux with thionyl chloride (3 ml, excess) for three hours, until HCl evolution ceased. The benzene and excess thionyl chloride were evaporated in vacuo, the residue taken up in more benzene (4 ml) and that too was evaporated. The pale yellow oily residue was dissolved in chloroform (3 ml), cooled in an ice-bath and added to an ice-cold aqueous solution comprising NaOH (0.5 g, 0.0125 mole) and 30% hydrogen peroxide (1.4 ml, 0.012 3 mole) and stirred in an icebath for 95 minutes. The layers were separated and the aqueous layer was extracted with chloroform (10 ml). The combined organic layers were dried with anhydrous $MgSO_4$. The solvent was evaporated in vacuo, leaving a white solid, 1.97 g. This was taken up in methanol (3 ml) and the insoluble $^{13}C_{12}$-benzoyl peroxide was filtered off and dried, producing 1.17 g, m.p. 104-5°C (litt. m.p. 104-6°C). $^{13}C_6$-Benzoic acid (0.150 g) was recovered from the aqueous alkaline layer by acidification and extraction. The yield based on consumed benzoic acid was 93%. The benzoyl peroxide had the expected NMR spectra: ^{1}H-NMR (400 MHz) δ 7.2-8.4 complex multiplets, Ar-H), ^{13}C-NMR (400 MHz) triplets with further splitting centred at δ 125.3 and 134.2, and a quintet with further splitting, centred at δ 129.2, in accord with the expected positions.

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