(Perfluoroacyl)thiophens. Part II.[1] Fluorination of Hexafluoro-1,3-di-(2-thenoyl)propane

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Improved yields of hexafluoro-1,3-di-(2-thenoyl)propane are obtained by the reaction of perfluoroglutaric acid with a large excess of 2-thienylmagnesium bromide. The diketone has been successfully fluorinated with sulphur tetrafluoride to give decafluoro-1,5-di-(2-thienyl)pentane and a small quantity of material believed to be octafluoro-2,6-di-(2-thienyl)pyran. Mild nitration of the former gives a mixture of isomeric dinitro-derivatives.

IN connection with studies on (perfluoroacyl)thiophens we have been interested in the synthesis of (perfluoroalkyl)thiophens and in particular αω-dithienylperfluoroalkanes. Although the chemistry of the alkylthiophens has been adequately reviewed,[2,3] examples of (perfluoroalkyl)thiophens are scarce. 2,3,4,5-Tetrakis (trifluoromethyl)thiophen has been obtained in low yield by ring closure of 1,2-bis(trifluoromethyl)acetylene with sulphur.[4] A few perfluoroalkenyl thiophens have been prepared in *ca.* 55% yield from 2-thienyl-lithium and perfluorovinyl halides.[5,6] This route is analogous to the direct alkylation of thiophens in moderate to good yield by reaction of 2-thienyl metals with alkyl halides.[7] However this procedure is not applicable as a general route to (perfluoroalkyl)thiophens, since 2-thienyl-lithium reacts with perfluoroalkyl halides to give good yields of 2-halogenothiophens (70—80%) and none of the desired (perfluoroalkyl)thiophen.

These results show that (perfluoroalkyl)thiophens cannot be prepared by direct perfluoroalkylation of the

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[2] H. D. Hartough, ' Thiophen and its Derivatives,' Interscience, New York, 1952, ch. VI.

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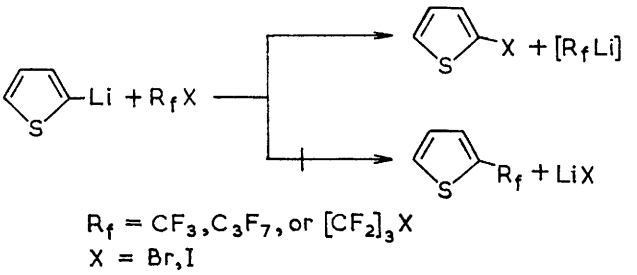
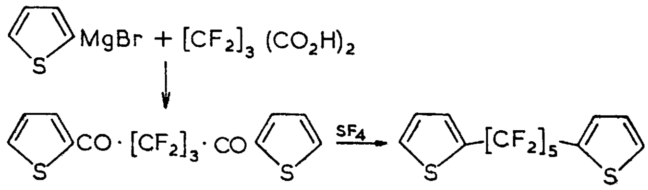
thiophen ring. The applicability of a two-stage synthesis was, therefore, studied in which the thiophen was converted into a perfluoroacyl derivative and subsequently fluorinated to give the desired (perfluoroalkyl)-thiophen.



Only a few (perfluoroacyl)thiophens have been reported.[8-10] Recently we described the preparation of hexafluoro-1,3-di-(2-thenoyl)propane (I) (37%) from 2-thienylmagnesium bromide and perfluoroglutaryl dichloride.[1] We have since improved the yield of (I) by use of perfluoroglutaric acid rather than the acid chloride by the method of Yakubovich *et al.*[11] A large excess of Grignard reagent is necessary to achieve a good yield of ketone. For example, the addition of 2-thienylmagnesium bromide (8 mol.) to fluoro-acid (1 mol.) gave a 60% yield of (I). With a 6 : 1 molar ratio, the yield of (I) was reduced to 35% and with a 2 : 1 molar ratio, no diketone was obtained; the sole reaction product was thiophen-2-carboxylic acid. This latter result is similar to that encountered when other fluoro-acids are treated with 2-thienyl-lithium[1] or phenyl-lithium.[12]

By analogy with the reduction of acylthiophens to alkythiophens, fluorination of the carbonyl group in the (perfluoroacyl)thiophens offers a route to (perfluoroalkyl)thiophens. Sulphur tetrafluoride reacts specifically with carbonyls to give perfluoromethylene derivatives usually in high yield.[13,14]

Hexafluoro-1,3-di-(2-thenoyl)propane (I) was best converted into decafluoro-1,5-di-(2-thienyl)pentane (II)



(I) (II)

by use of a 10 : 1 molar ratio of sulphur tetrafluoride to diketone and a reaction temperature of 240—250°, although the yield of product was only 40%. With use of higher temperatures the mixture charred rapidly, and at temperatures lower than 220° no reaction was observed.

The perfluoromethylene group in (II) should exert a strong electron-withdrawing effect and consequently deactivate positions 3 and 5 of the thiophen ring. Hence electrophilic substitution should be directed, at least partially, towards the 4-position. Mild nitration of (II) gave a mixture of isomeric dinitro-compounds. N.m.r. analysis showed that competitive substitution had occurred between the 4- and 5-positions in the proportion of 1 : 3. Further work to separate and fully characterise these isomers will be reported later.

Yakubovich and Zaitseva[14] reported a by-product from the fluorination of αω-dibenzoyl perfluoroalkanes which they identified as the partially fluorinated monoketone, characterised as its oxime. This was claimed as evidence for the stepwise fluorination of the two carbonyl groups in these diketones. We failed to isolate a similar monoketone on fluorination of (I). However, a small amount (2%) of a colourless oil was obtained by preparative g.l.c. The i.r. spectrum showed the absence of the carbonyl function, and chemical tests for this group were also negative. Microanalysis indicated an empirical formula $C_{13}H_6F_8OS_2$, and the mass spectrum showed a molecular ion at *m/e* 394; the breakdown pattern was as expected for a cyclic ether, octafluoro-2,6-di-(2-thienyl)pyran. The i.r. spectrum was similar to that of (II) but showed additional absorptions in the CF_2 region at 1100 cm.$^{-1}$, ascribed to the presence of an ether linkage.[15] Other examples of cyclic ether formation have also been recorded during fluorination with sulphur tetrafluoride, *e.g.* with tricarballylic acid and diglycollic acid.[13]

EXPERIMENTAL

I.r. spectra were recorded with a Perkin-Elmer 257 grating spectrophotometer and n.m.r. spectra at 60 Mc./sec. either with a Perkin-Elmer R10 or with a Varian A60 spectrometer (with tetramethylsilane as internal standard).

Reaction of 2-Thienyl-lithium with Perfluoroalkyl Halides.—The general procedure is exemplified in the reaction of 2-thienyl-lithium with 1,3-dibromohexafluoropropane.

An ethereal solution of 2-thienyl-lithium (0·1 mole)[16] was cooled to −65° under nitrogen and 1,3-dibromohexafluoropropane[17] (15·5 g., 0·05 mole) in dry ether (50 ml.) was added, dropwise, with the temperature maintained below −60°. The mixture was warmed slowly to room temperature, then refluxed gently for 2 hr., cooled, and hydrolysed with ice–hydrochloric acid. The organic layer was dried ($MgSO_4$) and distilled to give 2-bromothiophen (11·5 g., 70·5%), b.p. 149—150° (lit.,[18] 150°) together with

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2,5-dibromothiophen (2·0 g., 8·3%), b.p. 205—210° (lit.,[18] 210°).

Hexafluoro-1,3-*di*-(2-*thenoyl*)*propane* (I).—A solution of perfluoroglutaric acid (12·1 g., 0·05 mole) in dry ether was added slowly to 2-thienylmagnesium bromide (0·40 mole) at −10°. The mixture was then refluxed for 2 hr., cooled, and hydrolysed with ice–hydrochloric acid. The organic layer was washed with water, decolourised with charcoal, and dried ($MgSO_4$). Removal of solvent left the diketone (I) (11·4 g., 61%), m.p. 60° (from methanol) (lit.,[1] 59—60°) (Found: C, 41·8; H, 1·7; F, 29·9; S, 16·9. Calc. for $C_{13}H_6F_6O_2S_2$: C, 41·9; H, 1·6; F, 30·6; S, 17·2%), also characterised as its mono-2,4-dinitrophenylhydrazone, m.p. 120° (lit.,[1] 120°).

Fluorination of Hexafluoro-1,3-*di*-(2-*thenoyl*)*propane* (I).—A stainless steel autoclave containing hexafluoro-1,3-di-(2-thenoyl)propane (10·0 g., 0·026 mole) was cooled under liquid nitrogen and evacuated to *ca.* 1·0 mm. Sulphur tetrafluoride (30·0 g., 0·28 mole) was admitted slowly and, after a short period to ensure condensation of the gas, the apparatus was sealed. The mixture was heated for 20 hr. at 185° and for 47 hr. at 250°, then cooled to room temperature. Gases were released through sodium hydroxide solution. The product was composed of a brown, ether-soluble oil (7·5 g.) and an insoluble dark brown polymeric solid. The oil was washed with sodium carbonate solution and water and dried ($MgSO_4$). After chromatographic separation [alumina column; petroleum (b.p. 60—80°) eluant], a pale yellow oil was obtained (5·1 g.). Preparative g.l.c. separation (SE 30 column at 150°) gave two fractions. The first was *decafluoro*-1,5-*di*-(2-*thienyl*)*pentane* (II) (4·3 g., 40%), b.p. 80—82°/0·01 mm. (Found: C, 37·7; H, 1·7; F, 46·2; S, 15·3. $C_{13}H_6F_{10}S_2$ requires C, 37·5; H, 1·4; F, 45·7; S, 15·4%), $\nu_{max.}$ 1250s and 1100s cm.$^{-1}$ (CF_2)[15] and the 2-thienyl substitution pattern[19] between 1000 and 700 cm.$^{-1}$, τ 2·45, 2·60, and 2·90 (3 kinds of aromatic proton, 5-, 4-, and 3- respectively; $J_{3,5}$ 1·3, $J_{3,4}$ 3·5, and $J_{4,5}$ 5·0 c./sec.).

The second fraction was a pale yellow oil, probably *octafluoro*-2,6-*di*-(2-*thienyl*)*pyran* (0·2 g., *ca.* 2%), b.p. 188—90°/0·1 mm. (Found: C, 39·7; H, 1·7; F, 39·0; S, 16·0. $C_{13}H_6F_8OS_2$ requires C, 39·6; H, 1·5; F, 38·6; S, 16·2%), *m*/*e* 394 (M^+); breakdown pattern as expected for a cyclic ether.

Nitration of Decafluoro-1,5-*di*-(2-*thienyl*)*pentane* (II).—Decafluoro-1,5-di-(2-thienyl)pentane (II) was dissolved in glacial acetic acid (5·0 ml.) and slowly added to a stirred mixture of fuming nitric acid (10 ml.) and glacial acetic acid (5 ml.), cooled to 10°. After 2 hr. at room temperature the mixture was poured into excess of ice–water. The isomeric dinitro-compounds separated out; m.p. 126—130° (from methanol) (Found: C, 30·9; H, 1·1; F, 37·3; N, 5·7; S, 12·4. $C_{13}H_4O_4F_{10}N_2S_2$ requires: C, 30·8; H, 0·8; F, 37·5; N, 5·6; S, 12·6%).

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