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A NEW METHOD FOR THE PREPARATION OF α-(PERFLUOROALKYL) CARBONYL AND γ-(PERFLUOROALKYL)-α,β-UNSATURATED CARBONYL COMPOUNDS

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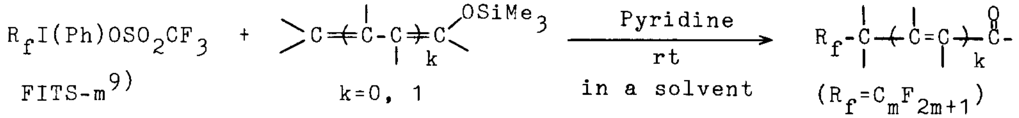
$R_fI(Ph)OSO_2CF_3$ or $R_fI(Ph)OSO_3H$ smoothly reacted with various trimethylsilyl enol ethers under mild conditions to give α-(perfluoroalkyl) carbonyl and γ-(perfluoroalkyl)-α,β-unsaturated carbonyl compounds in high yields.

It was reported that perfluoroiodoalkanes were allowed to react with enamines under heating or irradiating followed by acidic hydrolysis to give α-(perfluoroalkyl) carbonyl compounds in low yields.[1] The similar reaction of enamines with perhaloalkanes such as CF_2Br_2, CF_2BrCl, and $BrCF_2CF_2Br$ was recently described.[2] The irradiation of a solution of the ethyl enol ether of 17α-acetoxyprogesterone in a perfluoroiodoalkane followed by the acidic hydrolysis has been known as an only synthetic method for γ-(perfluoroalkyl)-α,β-unsaturated carbonyl compounds.[3]

Previously we have reported the successful perfluoroalkylations of carbanions, alkenes, alkadienes, arenes, and thiols with (perfluoroalkyl)phenyliodonium trifluoromethanesulfonates (FITS) or -sulfates (FIS) as cationic perfluoroalkylating agents.[4-8] In this communication, we wish to report a new useful preparative method for α-(perfluoroalkyl) carbonyl and γ-(perfluoroalkyl)-α,β-unsaturated carbonyl compounds from trimethylsilyl enol ethers using FITS or FIS.

It was found that FITS smoothly reacted with various trimethylsilyl enol ethers in an appropriate solvent at room temperature in the presence of 1.1 equivalent amounts of pyridine as a base without the subsequent acidic hydrolysis to give α-(perfluoroalkyl) carbonyl and γ-(perfluoroalkyl)-α,β-unsaturated carbonyl compounds in high yields and iodobenzene was liberated quantitatively.

Scheme 1.



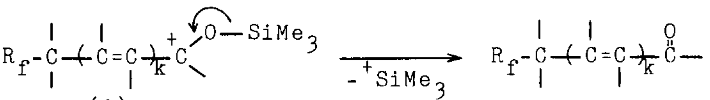
$$R_fI(Ph)OSO_2CF_3 + {>}C{=}\!\left(C{-}C\right)_k\!{=}C{<}^{OSiMe_3} \xrightarrow[\text{in a solvent}]{\text{Pyridine}\;/\;\text{rt}} R_f{-}C{-}\left(C{=}C\right)_k{-}\overset{O}{\overset{\|}{C}}{-}$$

FITS-m[9] k=0, 1 $(R_f=C_mF_{2m+1})$

The following procedure is typical. Acetone trimethylsilyl enol ether (0.6 mmol) was added into a solution of FITS-8 (0.5 mmol) and pyridine (0.55 mmol) in methylene chloride (3 ml) at room temperature with stirring. After 1 h, the reaction mixture was evaporated up and column-chromatographed on silica gel for a short period using pentane-ether (10:1) as an eluent to afford α-heptadecafluorooctylacetone as an oily product in a 88% yield.

It was found that (perfluoroalkyl)phenyliodonium sulfates (FIS)4), R_fI(Ph)-OSO$_3$H, cheaper than FITS, also reacted with the silyl enol ethers under the similar conditions except for the use of 2.2 equivalent amounts of pyridine to give the same carbonyl compounds in high yields. Table 1 summarizes the results of the reaction of FITS or FIS with various trimethylsilyl enol ethers.

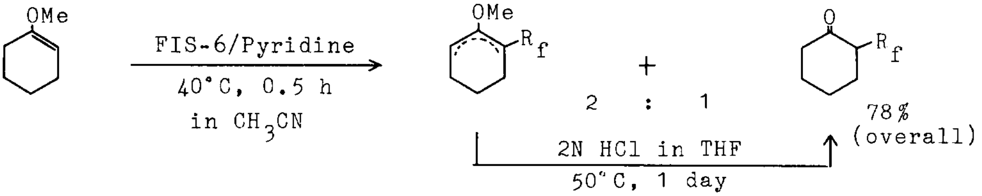
The reaction mechanism via a cationic intermediate (A) is proposed in analogy with the case of the reactions with alkenes and alkadienes.8) The products can be obtained by the elimination of the silyl cation from the cationic intermediate.



(A)

On the other hand, FIS reacted with the methyl enol ether of cyclohexanone in the presence of the base to produce a 1:1:1 mixture of three components containing the α-(perfluoroalkyl) ketone. By the treatment of the mixture with 2N hydrochloric acid in THF at 50°C for 1 day, the other two components could be converted to the (perfluoroalkyl) ketone (78% overall yield) as shown in Scheme 3. In this way, the acidic hydrolysis is required in the case of the alkyl enol ethers different from the silyl enol ethers.

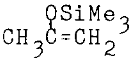
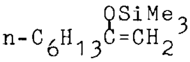
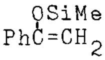
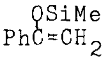
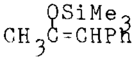
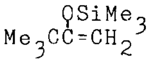
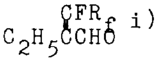
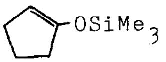
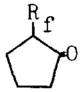
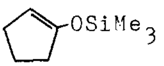
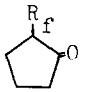
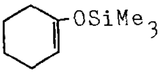
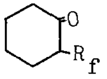
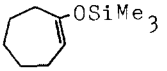
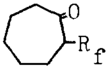
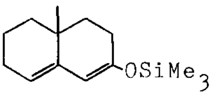
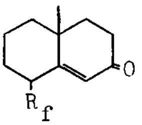
Scheme 3.



In general, α-(perfluoroalkyl) carbonyl and γ-(perfluoroalkyl)-α,β-unsaturated carbonyl compounds tend to undergo the elimination of hydrogen fluoride. In Run 1, 2, 3, 4, 6, 9, and 12, the partial elimination took place even during column-chromatography on silica gel. In Run 7, the chromatography resulted in the complete elimination.

The easy elimination of hydrogen fluoride in the perfluoroalkyl compounds is valuable in the viewpoint of the organic synthesis. Thus the treatment of α-(perfluoroalkyl) carbonyl and γ-(perfluoroalkyl)-α,β-unsaturated carbonyl compounds with a base could easily lead to the formation of β-(perfluoroalkyl)-α,β=unsaturated carbonyl and δ-(perfluoroalkyl)-α,β,γ,δ-unsaturated carbonyl compounds, respectively, which are expected as versatile intermediates for the preparation of various interesting perfluoroalkyl compounds (Scheme 4). As exemplified in Scheme 5, it is possible to synthesize some kinds of compounds

Table 1. Reaction of FITS-m or FIS-m with silyl enol ethers[a)]

Run	Silyl ether	FITS-m[b)] FIS-m	Solv[c)]	Temp (°C)	Time (h)	Product[d)]	Yield[e)] (%)	^{1}H-NMR[f)] (C$\underline{H}$-CF)
1	 $CH_3\overset{\mathrm{OSiMe_3}}{C}=CH_2$	FITS-8	A	rt	1	$CH_3COCH_2R_f$	88	3.12 (t,18.4)
2	 $n\text{-}C_6H_{13}\overset{\mathrm{OSiMe_3}}{C}=CH_2$	FITS-2	B	rt	ON[g)]	$n\text{-}C_6H_{13}COCH_2R_f$	77	3.10 (t,18)
3	 $Ph\overset{\mathrm{OSiMe_3}}{C}=CH_2$	FITS-3i[h)]	A	rt	2	$PhCOCH_2R_f$	79(91)	3.62 (d,10.4)
4	 $Ph\overset{\mathrm{OSiMe_3}}{C}=CH_2$	FIS-2	A	reflux	0.7	$PhCOCH_2R_f$	85	3.64 (t,17)
5	 $CH_3\overset{\mathrm{OSiMe_3}}{C}=CHPh$	FIS-2	A	reflux	1	$CH_3COCH(Ph)R_f$	59	4.34 (dd,18, 12)
6	 $Me_3C\overset{\mathrm{OSiMe_3}}{C}=CH_2$	FITS-8	B	rt	0.5	$Me_3CCOCH_2R_f$	82	3.24 (t,18)
7	$C_2H_5CH=CHOSiMe_3$	FITS-8	B	rt	1	 $C_2H_5\overset{\mathrm{CFR_f}}{C}CHO$ i)	65	9.87(s) 10.20(s)
8		FIS-8	B	45	0.5		76	2.85 (m)
9		FIS-10	B	40	1		80	2.8 (m)
10		FITS-6	B	rt	0.7		71	3.16 (m)
11		FIS-6	B	45	0.5		83	3.27 (m)
12	$CH_2=CHCH=CHOSiMe_3$	FIS-8	A	rt	4	$R_fCH_2CH=CHCHO$[j)]	54(70)	3.10 (td,17.2, 6.8)
13		FITS-3	A	rt	2		85	2.9-3.4[k)] (m)

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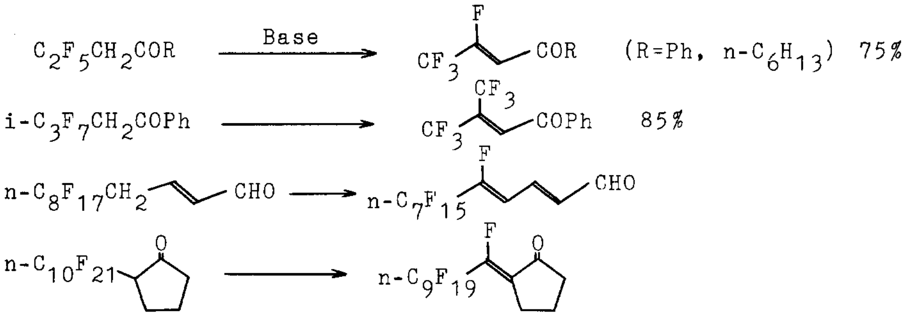
a) Pyridine was used as a base in all cases. b) See (9) in References and Notes. c) A=CH_2Cl_2, B=CH_3CN. d) Structures were confirmed by means of NMR, IR, and Mass spectral data. e) Isolated yields (GLC yields). f) Chemical shifts of C$\underline{H}$-CF are given in δ ppm in $CDCl_3$ except for Run 7 where chemical shifts of C$\underline{H}$O are given. Values in parentheses are coupling constants (Hz). g) Overnight. h) See (4) in References and Notes. i) A 2:1 mixture of stereoiomers. j) trans-Isomer. k) When α-CF_2 was irradiated, the multiplet changed into a doublet with a coupling constant of 6 Hz.

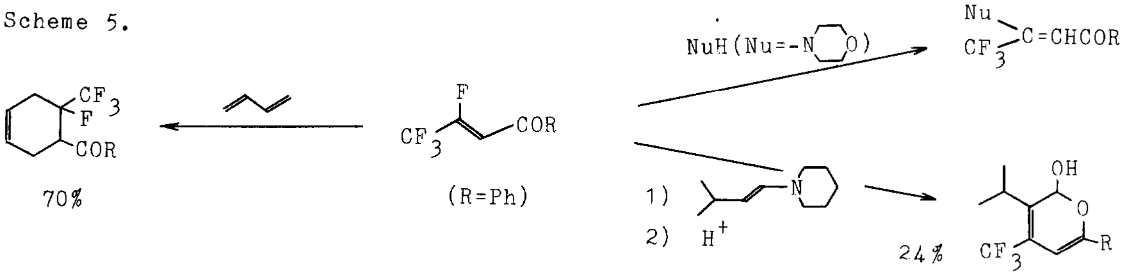
Scheme 4.



possessing the trifluoromethyl groups which are unique functional groups in the biological activity.[10)]

As mentioned above, FITS or FIS can smoothly react with various silyl enol ethers under the mild conditions without the subsequent hydrolysis to afford the (perfluoroalkyl) carbonyl compounds in high yields. Since a wide range of silyl enol ethers can easily be prepared by the advanced synthetic methods,[11)] our technique using FITS or FIS offers a promising synthetic method for many kinds of perfluoroalkyl-substituted carbonyl compounds.

Scheme 5.



References and Notes

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7) T.Umemoto and Y.Kuriu, Chem. Lett., 1982, 65.
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9) The letter m means the number of carbons in a n-perfluoroalkyl group. When m=3i, 3i means an isoheptafluoropropyl group.
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