

Difluoroiodomethane: Practical Synthesis and Reaction with Alkenes

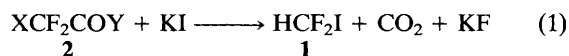
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Difluorocarbene precursors **2**, FSO₂CF₂COF, FSO₂CF₂CO₂H, FSO₂CF₂CO₂Me and XCF₂CO₂M react with KI to give HCF₂I **1** in high yields; a smooth reaction of **1** with alkenes or alkynes in the presence of Na₂S₂O₄ gives the difluoromethylated adducts in good yields.

In difluorocarbene chemistry, difluoromethanes, HCF₂Cl, HCF₂Br, HCF₂I are important precursors.¹ However, iododifluoromethane, HCF₂I **1**, has received little attention.²⁻⁴ In comparison with HCF₂Cl and HCF₂Br, reduced application of **1** may be ascribed to its availability. Previously, **1** was prepared inconveniently by fluorination of iodoform with HgF⁵ or hydrolysis of bromodifluoromethyltriphenyl phosphonium bromide [Ph₃PCF₂Br]⁺Br⁻ in the presence of an excess of NaI.⁶

We found that **1** can be obtained from the available difluorocarbene precursors **2**, *i.e.* FSO₂CF₂CO₂H,^{7a} FSO₂CF₂CO₂Me,^{7b} BrCF₂CO₂K, ClCF₂CO₂K, BrCF₂CO₂H, ClCF₂CO₂H, FSO₂CF₂COF with potassium iodide. Treatment of **2** with KI under appropriate conditions gave **1**, see Table 1.†



2a	FSO ₂ CF ₂ COF
b	FSO ₂ CF ₂ CO ₂ H
c	FSO ₂ CF ₂ CO ₂ Me
d	BrCF ₂ CO ₂ K
e	ClCF ₂ CO ₂ K
f	BrCF ₂ CO ₂ H
g	ClCF ₂ CO ₂ H

Table 1 Reaction of **2** with potassium iodide (KI: **2** = 2:1)

Entry	2	Solvent	Time/h	Temp./°C	Yield (%) ^a
1	a ^b	MeCN ^c	0.5	30–40	80
2	b	MeCN ^c	5	40	80
3 ^d	c	Bu ⁿ OH	5	60	73
4 ^e	d	DMF ^c	6	80	74
5 ^e	e	DMF ^c	6	80	75
6 ^e	f	DMF ^c	6	80	77
7 ^e	g	DMF ^c	7	90	70

^a Isolated yields based on **2**, besides **1**, CO₂, SO₂ (for **2a**, **2b** and **2c**) were identified by GC-MS. ^b NaHCO₃:KI: **2a** = 1:2:1. ^c Containing a trace of water. ^d BuⁿOFCF₂H, a difluorocarbene insertion product, was also obtained in 5% yield (determined by ¹⁹F NMR spectroscopy) based on **2**. ^e CuI was added, KI:CuI: **2** = 2:1:1.

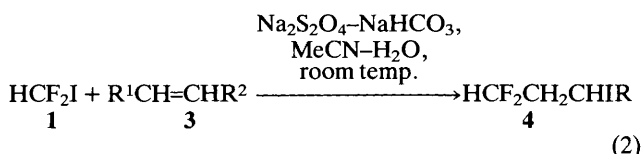
Table 2 Results of **1** with alkenes **3** and alkynes **5**^a

Entry	3 or 5	Time/h	Yield (%) ^b	<i>E</i> : <i>Z</i> ^c
1	3a	14	86	
2	3b	15	70	
3	3c	6.5	60	
4	3d	12	69 ^d	
5	3e	12	50	1:3
6 ^e	5a	6	64	1:2
7	5b	6	60	1:3

^a All the reactions were carried out in MeCN–H₂O (1:1.2 v/v) at room temp., **1**:**3** or **5**:Na₂S₂O₄:NaHCO₃ = 1:1:2:2. ^b Isolated yields based on **1**. The structures of all products were identified by elemental analyses, IR, ¹⁹F NMR, ¹H NMR and mass spectroscopy. ^c Determined by ¹⁹F NMR spectroscopy. ^d **4a**, HCF₂CH₂CHCH₂OCH₂CHCH₂I. ^e Reaction temp. 40°C.

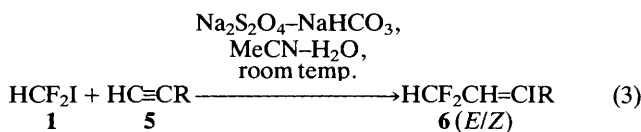
Similar to those reported previously,⁸ the mechanism of the formation of **1** is that the difluorocarbene generated from these precursors combines with the iodide ion to give ICF₂⁻, which is captured by a proton donor, *e.g.* HI, H₂O or BuⁿOH to afford the final product **1**.

There was no record on the reaction of **1** with ordinary alkenes or alkynes except the photochemical reaction of **1** with ethylenes.² It was found better to use Huang's sulfinate-dehalogenation method⁹ to synthesize the difluoromethylated products from alkenes or alkynes under very mild conditions. Treatment of **1** with alkenes **3** in the presence of sodium dithionite in aqueous MeCN at room temp. for 6–15 h gave the adducts **4** in good yields, eqn. (2).†



3: **a**: R¹ = H, R² = Buⁿ; **b**: R¹ = H, R² = *n*-C₅H₁₁; **c**: R¹ = H, R² = MeCO₂CH₂CH₂-; **d**: R¹ = H, R² = CH₂=CHCH₂-OCH₂-; **e**: R¹ = R² = -(CH₂)₂-

Similarly, alkynes **5** reacted with **1** gave alkenes **6**, eqn. (3). All the results are listed in Table 2.



5: **a**: R = Buⁿ; **b**: R = Ph

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Footnote

† Typical procedure for the preparation of **1** and **4**: For **1**: KI (93 g, 0.6 mol) and MeCN (250 ml) were placed in a 500 ml three-necked round-bottomed flask equipped with thermometer and magnetic stirrer. When the mixture was heated to 40°C, **2b** (53 g, 0.3 mol in 20 ml MeCN) was added dropwise during 2 h. Then the reaction temp. was raised to 60°C and heated for another 2 h. On completion **1** was distilled out and collected in a trap cooled to -78°C and further purification through trap to trap distillation gave 42 g of pure **1** (80%): bp 21–23°C (20°C), ¹⁹F NMR δ_F: (CFCl₃) -68 (d, *J* 56 Hz), δ_H: 8.1, MS *m/z* 178 (M⁺, 100), 51 (M⁺ - I, 25), 127 (I⁺, 64).

Preparation of **4b**: Hept-1-ene (0.98 g, 10 mmol), Na₂S₂O₄ (3.48 g, 20 mmol), NaHCO₃ (1.68 g, 20 mmol), 6 ml MeCN, 7 ml H₂O and **1** (1.78 g, 10 mmol) were placed in a 100 ml two-necked flask equipped with magnetic stirrer and thermometer. After stirring at room temp. for 15 h, the reaction mixture was treated with 20 ml water, the aqueous layer was extracted with diethyl ether (3 × 20 ml). After usual work-up **4b** (1.93 g, 70%) was obtained, bp 88–90°C ¹⁹F NMR

δ_{F} : -117 (m), δ_{H} : 5.97 (dddd, J 54.9, 54.3, 6.42, 3.05 Hz, 1H), 4.05 (m, 1H), 2.3-0.8 (13H); MS m/z : 149 ($M^+ - I$, 18), 127 (I^+ , 10), 65 ($\text{HCF}_2 - \text{CH}_2^+$, 12), 57 (C_4H_9^+ , 100), IR: ν/cm^{-1} 1480-1380, 1480-1380, 1180-1080.

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