A General and Efficient Route for the Preparation of Phenyl-Substituted Vinyl Fluorides[1])

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α-Fluorobenzyl phosphonate $(EtO)_2P(O)CFHPh$ (**2**) prepared from diethyl α-hydroxyphosphonate $(EtO)_2P(O)CH(OH)Ph$ (**1**) and diethylaminosulfur trifluoride (DAST), reacts with bases such as butyllithium, *tert*-butyllithium, lithium bis(trimethylsilyl)amide, or lithium diisopropylamide at $-78°$ in THF to give the phosphonate carbanion $[(EtO)_2P(O)CFPh]^-Li^+$ (**3**) which was detected by acylation with propionyl chloride or by addition of MeOD to the reaction mixture to give $(EtO)_2P(O)CF(COEt)Ph$ (**4**) and $(EtO)_2P(O)CFDPh$ (**5**), respectively. Addition of aldehydes or ketones to a THF solution of carbanion **3** led to moderate-to-good yields of phenyl-substituted vinyl fluorides RR′C=CFPh **6**. The stereoselectivity of the products PhCH=CFPh (**6a**) and Ph(Me)C=CFPh (**6i**) formed in the reaction was examined. The presence of hexamethylphosphoric triamide or *N,N′*-dimethylpropyleneurea as cosolvent in the preparation of **6a** and **6i** increased the (*Z*)-stereoselectivity. However, the presence of LiCl in THF did not alter the (*E*)/(*Z*)-ratio of the product.

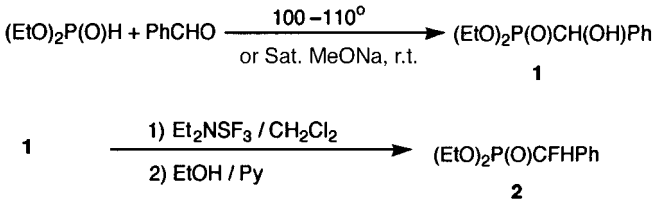
Introduction. – Profound changes in the biological activity of an organic compound are often associated with the replacement of a H-atom in the molecule by an F-atom [2]. Replacement of the H-atom by the F-atom not only enhances the biological activity of parent compounds but also increases their thermal and oxidative stabilities [3]. A variety of monofluoro compounds exhibit remarkable biological activities [4], and medical and biological sciences exert an increasing demand for fluorinated organic compounds. Biologically active molecules containing a vinylic F-atom are of special interest, as this moiety is present in a number of enzyme inhibitors [5]. The main methods currently afford vinyl fluorides in which the accompanying terminal group is a halogen [6], ester [7], cyanide [8], or sulfone [9] function. Consequently, the synthesis of selectively fluorinated building blocks, such as phenyl-substituted fluoro alkenes, has become an area of interest in recent years [10–12]. Literature methods for the preparation of phenyl-substituted fluoro alkenes generally lack generality and stereoselectivity. Thus, addition of elemental fluorine to prop-1-enylbenzene followed by subsequent dehydrofluorination gives (*Z*) and (*E*)-1-fluoroprop-1-enylbenzenes [10]. Dehydrofluorination of *erythro*- and *threo*-difluorides PhCFHCFHPh with *t*-BuOK produces α-fluoro *cis*- and *trans*-α-fluorostilbene [11]. Dehydroiodination of 1-fluoro-2-iodo-1-phenylpropane also leads to the preparation of *cis*- and *trans*-(1-fluoroprop-1-enyl)benzenes [12]. Recent research from our laboratory has focused on the use of fluoroethoxycarbonyl-substituted phosphorus or phosphonate ylides as synthons for the preparation of α-fluorocarbonyl compounds such as α-fluoro-α,β-unsaturated esters [13], α-fluoro-β-keto esters [14], α-fluoro-α-alkyl esters [15], and α-fluoro-α,β-

[1]) For a preliminary communication, see [1].

unsaturated diesters [16]. Herein, we describe a general, one-pot synthesis of Ph-substituted vinyl fluorides RR′C=CFPh, which permits variation of the group in the β-position from the reaction of diethyl α-fluorobenzylphosphonate carbanion $[(EtO)_2P(O)CFPh]^-Li^+$ (**3**) with aldehydes and ketones.

Results and Discussion. – Thermal non-catalyzed addition of diethyl phosphite to PhCHO [17] at 110°, or MeONa-catalyzed condensation of diethyl phosphite with PhCHO at room temperature [18] gave the diethyl α-hydroxyphosphonate $(EtO)_2P(O)CH(OH)Ph$ (**1**) in 53% yield. The ^{31}P-NMR spectrum of **1** can be observed as a *doublet* of quintuplets at 21.6 ppm (J(P,CH) = 10, J(PO,CH) = 7 Hz). J(P,CH) and J(PO,CH) values were obtained by selective irradiation of H–C(α) at 4.1 ppm and CH_2 H-atom at 5.0 ppm. The signal corresponding to the OH H-atom was confirmed by the ^{1}H-NMR spectrum measured by addition of D_2O to the sample in NMR tube. The signal at 5.2 ppm disappeared after H/D exchange reaction. The conversion of the OH group into the F-substituent was achieved by the reaction of **1** with diethylaminosulfur trifluoride (DAST) in CH_2Cl_2 to obtain diethyl α-fluorobenzylphosphonate $(EtO)_2P(O)CFHPh$, **2**, in 53% yield (*Scheme 1*) [19].

Scheme 1

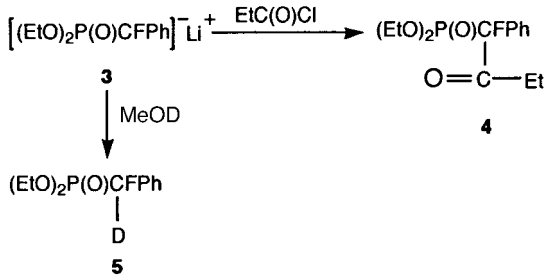


Deprotonation of H–C(α) from phosphonate **2** was conveniently carried out at –78° in THF with organolithium reagents such as BuLi, *t*-BuLi, lithium bis(trimethylsilyl)amide, and lithium diisopropylamide (LDA) to give similar results. No reaction occurred when NaH was used as a base at –78° or 40° in THF. The α-fluorobenzylphosphonate carbanion $[(EtO)_2P(O)CFPh]^-Li^+$ (**3**) decomposed at room temperature. Nevertheless, the acid-base reaction between phosphonate **2** and LDA at –78° could be detected by acylation of the product carbanion **3** with propionyl chloride to give a *doublet* (J(F,P) = 76 Hz) at –170 ppm in the ^{19}F-NMR spectrum for the acylated compound $(EtO)_2P(O)CF(COEt)Ph$ (**4**) in 80% yield (^{19}F-NMR). Phosphonate carbanion **3** could also be detected by addition of MeOD to the reaction mixture to afford $(EtO)_2P(O)CFDPh$ (**5**), which was not isolated but was identified by a *doublet* of *triplets* at –200 ppm in the ^{19}F-NMR spectrum, with coupling constants of 83 and 7 Hz, respectively (*Scheme 2*).

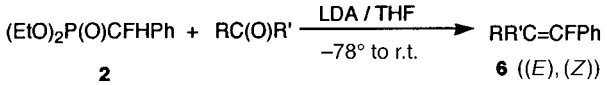
Treatment of diethyl α-fluorobenzylphosphonate **2** with LDA in the presence of aldehydes or ketones in THF at –78° gave phenyl-substituted vinyl fluorides RR′C=CFPh, **6**, in 47–76% isolated yields (*Scheme 3* and *Table 1*).

The initial step in the synthesis of fluoro alkenes **6** is nucleophilic attack of the carbanion **3** at the carbonyl C-atom of aldehydes or ketones to form ion **7**. Intra-

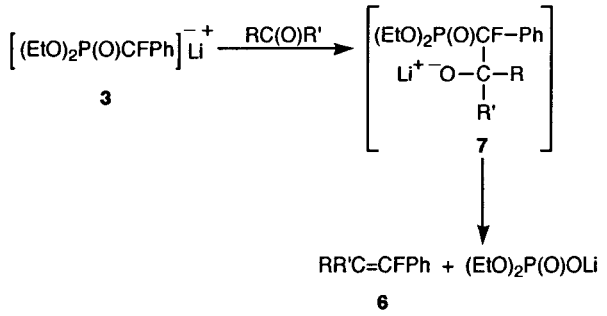
Scheme 2



Scheme 3



Scheme 4



molecular elimination of diethylphosphate anion from **7** affords the phenyl-substituted vinyl fluorides **6** (*Scheme 4*).

The results of the preparation of several Ph-substituted vinyl fluorides **6a**–**n** are summarized in *Table 1*.

The (*E*)/(*Z*) ratio of **6** was determined by integration of the F-signals in the ^{19}F-NMR spectra, which appear as *doublets* between – 89.4 and – 121.0 ppm upfield from $CFCl_3$ as an internal standard. The downfield chemical shifts (– 89.4 to – 102.7 ppm) were assigned to the F-atom of the (*E*)-isomer, whereas the upfield signals (– 105.5 to – 121.0 ppm) were assigned to the F-atom of the (*Z*)-isomer. The assignments of configuration are based on the reports that ^3J(H,F(*E*)) is larger than ^3J(H,F(*Z*)), and ^4J(H,F(*Z*)) is larger than ^4J(H,F(*E*)) in typical compounds that contain the moieties –*H*C=C*F*CO_2Et [20] and –*H*CC=C*F*CO_2Et [7][16], respectively. In the ^{1}H-NMR spectrum, the signal for the vinyl H-atom appears in the range of 5.7 to 6.5 ppm downfield from Me_4Si as an internal standard.

The (*E*)/(*Z*)-selectivity observed was *ca.* 1:1 in most of the reactions reported in *Table 1*. However, in the preparation of **6h**, the (*Z*)-isomer was obtained preferentially. This result may possibly be explained by the repulsive interactions between 3,4-$(MeO)_2C_6H_3$ and Ph groups [16].

Table 1. *Preparation of* **6** *from* **2**

No.	R	R′	(*E*)/(*Z*)[a])	Yield [%][b])
6a	Ph	H	46 : 54	71
6b	4-MeC_6H_4	H	50 : 50	66
6c	4-$MeOC_6H_4$	H	43 : 57	76
6d	4-ClC_6H_4	H	50 : 50	65
6e	4-$NO_2C_6H_4$	H	49 : 51	65[c])
6f	2-$CF_3C_6H_4$	H	60 : 40	74
6g	Cyclohexyl	H	47 : 53	72
6h	3,4-$(MeO)_2C_6H_3$	H	36 : 64	69
6i	Ph	Me	51 : 49	50
6j	Ph	Ph	–	48
6k	Me	Me	–	50[c])
6l	CD_3	CD_3	–	52[c])
6m	Me	Et	50 : 50	47[c])
6n	$-(CH_2)_5-$		–	54[c])

[a]) (*E*)/(*Z*)-Ratio was determined by ^{19}F-NMR integration of the vinyl-fluorine signals. [b]) Isolated yields are based on **2**. [c]) Yield based on ^{19}F-NMR; $PhCF_3$ as internal standard.

The stereoselectivity of **6a** and **6i** is dependent on the solvent, base, cosolvent, or metal ion present in the reaction mixture. Different isomer ratios obtained are listed in *Table 2*.

The use of LDA in a mixture of THF, and hexamethylphosphoric triamide (HMPT) or *N*,*N*′-dimethylpropyleneurea (DMPU) in the preparation of **6a** and **6i** increased (*Z*)-stereoselectivity. However, the presence of excess LiCl had no influence on the

Table 2. *Dependence of Configuration of* **6a** *or* **6i** *on Solvent, Base, Cosolvent, and Metal Ion*

$(EtO)_2P(O)CFHPh + PhC(O)R \xrightarrow[-78^\circ \text{ to r.t.}]{\text{Solvent/Base/Cosolvent/Metal ion}} Ph(R)C{=}CFPh$

2

((*E*),(*Z*))

6a R = H

6i R = Me

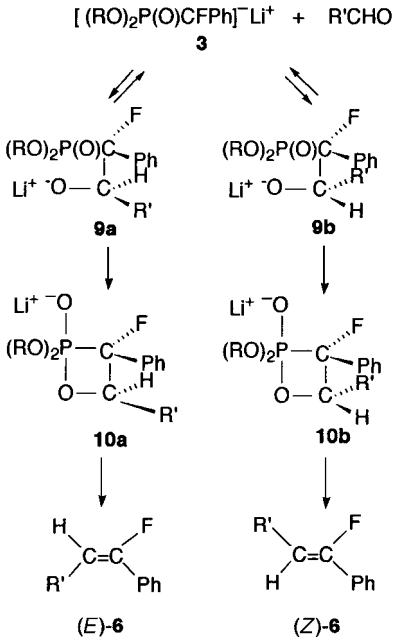
Entry	R	Solvent/Base/Cosolvent/Metal ion	(*E*)/(*Z*)	Yield [%][a])
1	H	THF/LDA/–/–	46 : 54	87
2	H	THF/LDA/HMPT/–	24 : 76	84
3	H	THF/LDA/DMPU/–	38 : 62	82
4	H	THF/LDA/–/2 LiCl	45 : 55	86
5	Me	THF/LDA/–/–	51 : 49	80
6	Me	THF/LDA/HMPT/–	38 : 62	74
7	Me	THF/LDA/DMPU/–	40 : 60	72
8	Me	THF/LDA/–/2 LiCl	50 : 50	75
9	Me	THF/BuLi/–/–	49 : 51	78
10	Me	THF/*t*-BuOK/–/–	65 : 35	62
11	Me	CH_2Cl_2/BuLi/–/–	48 : 52	72
12	Me	CH_2Cl_2/*t*-BuOK/–/–	66 : 34	63
13	Me	Et_2O/BuLi/–/–	46 : 54	73
14	Me	Et_2O/*t*-BuOK/–/–	60 : 40	52
15	Me	Hexane/LDA/–/–	57 : 43	71

[a]) Yields based on ^{19}F-NMR; $PhCF_3$ as internal standard.

configuration of **6a** and **6i** [16]. In the preparation of **6i**, the (*E*)/(*Z*)-ratio changed from 48 : 52 to 66 : 34 when the base was changed from BuLi to *t*-BuOK in CH_2Cl_2 as solvent. However, the stereoselectivity of **6i** was unaffected when the solvent was changed from THF to Et_2O or CH_2Cl_2 with the BuLi base. A higher yield (80%; ^{19}F-NMR) was observed with LDA as the base in THF. However, only a 52% yield (^{19}F-NMR) was observed with *t*-BuOK as base in Et_2O.

The formation of Ph-substituted fluoro alkenes is analogous to the *Wittig* reaction [21] and is illustrated in *Scheme 5*. The formation of the intermediate **9** from **3** and carbonyl compounds is reversible [22], and that intermediate can exist in two diastereoisomeric forms, **9a** and **9b** [13][16]. Complexation of soluble Li salts [23] with the intermediate **9** retards the reversibility between the isomers **9a** and **9b**. Consequently, each of these intermediates undergoes cyclization to **10a** and **10b**, respectively, and decomposition *via* a *syn* elimination to stereospecifically give the Ph-substituted fluoro alkenes (*E*)-**6** and (*Z*)-**6**. Thus, the *erythro*-form **9a** should lead to the (*E*)-isomer, while the *threo*-form should lead to the (*Z*)-isomer. Steric hindrance between the Ph and 3,4-$(MeO)_2C_6H_3$ groups should be greater in **9a** than **9b**, and irreversible decomposition of the isomers **9a** and **9b** should give specific Ph-substituted vinyl fluorides **6**. The relative rates of formation and decomposition of the intermediate should determine the (*E*)/(*Z*)-ratio. Slow decomposition of alkoxy anions should lead to increased reversibility of the initial step to form the (*Z*)-isomer as the major product [16]. The decisive influence of dissolved Li salts on the isomer ratio in *Wittig* and related reactions is well-documented [24]. Different isomer ratios are possible for (*E*)- and (*Z*)-PhCH=CFPh (**6a**), or (*E*)- and (*Z*)-Ph(Me)C=CFPh (**6i**), when the alkoxide

Scheme 5



ion **9a** or **9b** is associated with the Li cation, or if the cation is coordinated by HMPT or DMPU, and removed from the reaction site.

Conclusion. – We have demonstrated that treatment of phosphonate carbanion $[(EtO)_2P(O)CFPh]^-Li^+$, **3**, derived from diethyl α-fluorobenzylphosphonate and LDA with aldehydes or ketones provides a viable synthesis of Ph-substituted vinyl fluorides. Since the mild reaction conditions employed in this synthesis permit the presence of sensitive functionalities, this method allows for variation of groups in the β-position and affors the convenience of carrying out all the transformations in one pot from readily available starting materials.

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Experimental Part

General. THF was purified by distillation from sodium benzophenone ketyl. $(EtO)_2P(OH)H$, PhCHO, MeC(O)Me, cyclohexanone, CH_2Cl_2, and HMPT were distilled prior to use. LDA, $(Me_3Si)_2NLi$, *t*-BuLi, *t*-BuOK, LiCl, MeOD, and DAST were used without further purification. Aromatic aldehydes (4-MeC_6H_4CHO, 4-$MeOC_6H_4CHO$, 4-ClC_6H_4CHO, 4-$NO_2C_6H_4CHO$, 3,4-$(MeO)_2C_6H_3CHO$), cyclohexanecarbaldehyde, Et-C(O)Cl, PhC(O)Ph, and DMPU were used without further purification. Normality of BuLi was determined *via* procedures of *Duhamel* and *Plaquevent* [25] and *Bergbreiter* and *Pendergrass* [26]. NaH (80% dispersion in mineral oil) was washed with hexane prior to use. GLPC Analyses were performed on a 5% *OV-101* column with a thermal conductivity detector. FT-IR Spectra were recorded as CCl_4 solns. with a soln. cell of 0.1-cm path length. ^{19}F- (against internal $CFCl_3$), $\{^1H\}^{31}P$-NMR (against external 85% H_3PO_4), ^1H- and ^{13}C-NMR spectra (against internal TMS) were recorded on a *Bruker WM360X* spectrometer. All chemical shifts are reported in ppm downfield (positive) of the standard. MS Analyses were performed at 70 eV in the electron-impact (EI) mode on a single quadrapole instrument interfaced to a gas chromatograph fitted with an *OV-101* column. HR-MS Analyses were performed at 70 eV in the EI mode.

Preparation of Diethyl α-Hydroxybenzylphosphonate (*(EtO)$_2$P(O)CH(OH)Ph*). A 250-ml two-necked flask equipped with the septum port, a *Teflon*-coated magnetic stirbar, and a water condenser topped with a T tube leading to a source of N_2, and a mineral-oil bubbler was charged sequentially with 0.2 mol (27.6 g, 26 ml) of diethyl phosphite and 0.25 mol (26.6 g, 26 ml) of freshly distilled PhCHO. The contents of the flask were heated at 100–110° for 10 h, then filtered through a funnel to give 16 g (52%) of $(EtO)_2P(O)CH(OH)Ph$. M.p. 82–84°. IR: 3300 (br.), 3033*m*, 2983*m*, 2930*m*, 1392*s*, 1235*m*, 1034*m*. ^1H-NMR: 7.49 (*m*, 2 H); 7.35 (*m*, 3 H); 5.23 (1 H); 5.03 (*d*, $J = 10$, 1 H); 4.16 (*q*, $J = 7$, 4 H); 1.32 (*t*, $J = 7$, 6 H). ^{13}C-NMR: 128.2–127.0; 70.7 (*d*, $J(C,P) = 158$); 63.4; 63.1; 16.3; 16.2. ^{31}P-NMR: 21.6 (*dquint.*, $J(P,CH) = 10$, $J(PO,CH) = 7$). GC-MS: 245 (0.17, $[M+1]^+$), 244 (1.83, M^+), 215 (0.81, $[M-Et]^+$), 199 (0.64, $[M-OEt]^+$), 138 (23.33, $[M-PhCOH]^+$ or $[(EtO)_2P(O)+H]$), 111 (41.43), 106 (29.52), 105 (34.72), 82 (24.64), 79 (13.93), 77 (Ph^+).

Preparation of Diethyl α-Fluorobenzylphosphonate (*(EtO)$_2$P(O)CFHPh*). A 250-ml two-necked flask equipped with a septum port, a magnetic stirbar, and a water condenser topped with a T-tube leading to a source of N_2 and a mineral oil bubbler was charged with 20 ml CH_2Cl_2 and 19.2 mmol (3.12 g, 2.4 ml) of diethylaminosulfur trifluoride (DAST). The contents of the flask were cooled to −78° *via* a dry ice/i-PrOH slush bath. To the cooled soln., 16.4 mmol (4.0 g) of $(EtO)_2P(O)CH(OH)Ph$ in 40 ml of CH_2Cl_2 was added dropwise *via* syringe during 1 h. The mixture was allowed to warm to r.t. and stirred further for 2 h, then it was carefully quenched by pouring into a soln. of EtOH (120 ml) and pyridine (5 ml). After 1 h, this mixture was poured into ice-H_2O (400 ml) and extracted with CH_2Cl_2 (3 × 150 ml). The combined extracts were washed with dil. HCl (2 × 80 ml) and H_2O (2 × 60 ml), dried (anh. $MgSO_4$), filtered, and concentrated *in vacuo*. The residue was distilled at 100–102°/0.3 mm Hg ([19]: 110°/0.4 mm Hg) to obtain 2.1 g (52%) of the title compound (GLPC purity 99%). IR: 3067*m*, 2931*m*, 2910*m*, 2868*m*, 1392*s*, 1264*m*, 1029*m*. ^1H-NMR: 7.48 (*m*, 2 H); 7.36 (*m*, 3 H); 5.68 (*dd*, $^2J(H,F) = 45$, $^2J(H,P) = 8$, 1 H); 4.07 (*m*, 4 H); 1.25 (*t*, $^3J(H,H) = 7$, 3 H); 1.24 (*t*, $^3J(H,H) = 7$, 3 H). ^{13}C-NMR: 133.1–126.8; 89.4 (*dd*, $^1J(C,F) = 183$, $^1J(C,F) = 169$); 63.7 (*s*); 63.6 (*s*); 16.4 (*s*); 16.3 (*s*). ^{19}F-NMR: −200.4 (*dd*, $^2J(F,P) = 84$, $^2J(F,H) = 45$). ^{31}P-NMR: 16.4 (*ddquint.*, $^2J(P,F) = 84$, $^2J(P,H) = 8$, $^3J(P,H) = 7$). GC-MS: 246 (0.86, M^+), 218 (3.35, $[M-CH_2{=}CH_2]^+$), 217 (5.19, $[M-Et]^+$), 109 (100.00, $[M-(EtO)_2P(O)]^+$).

General Procedure for Preparation of **6** *as Described for (*E*)- and (*Z*)-(1-Fluoro-2-phenylethenyl)benzene* (**6a**). A 100 ml two-necked flask equipped with a septum port, a magnetic stirring bar, and a reflux water condenser topped with a T-tube leading to a source of N_2, and mineral-oil bubbler was charged sequentially with 16 ml of dry THF and 8.0 mmol (1.97 g) of $(EtO)_2P(O)CFHPh$. The contents of the flask were cooled to $-78°$ in a dry ice/i-PrOH slush bath. To the cooled soln., 10.5 mmol (7.0 ml) of a 1.5M cyclohexane soln. of LDA mono(tetrahydrofuran) was added dropwise *via* syringe. The resulting bright yellow soln. was stirred at $-78°$ for 30 min, then 10 mmol (1.06 g) of freshly distilled PhCHO were added dropwise *via* syringe. The resulting soln. was stirred at $-78°$ for 30 min. and then allowed to warm to r.t. over 4 h, and stirred at that temp. overnight. ^{19}F-NMR Analysis of the mixture indicated the absence of **2** and the formation of **6a**. The mixture was poured into H_2O (40 ml), and the aq. layer was extracted with Et_2O (3×40 ml). The combined org. layers were washed with dil. HCl until the washings were neutral. The resulting soln. was washed successively with brine (30 ml) and H_2O (30 ml), dried ($MgSO_4$), filtered, and concentrated *in vacuo*. The residue was purified by FC (120 g of silica gel, 200–425 mesh) eluting with hexane/AcOEt (24 : 1) to give 1.13 g (71%) of (*E*/*Z*)-**6a**. The (*E*)/(*Z*) ratio of **6a**, determined by the integration of the ^{19}F signals in the ^{19}F-NMR spectrum, was 46 to 54. (*E*)-**6a**: ^{1}H-NMR: 7.67–7.35 (*m*, 10 H); 6.45 (*d*, ^3J(H,F(*Z*)) = 22, 1 H). ^{19}F-NMR: −95.2 (*d*, ^3J(F,H(*Z*)) = 22). (*Z*)-**6a**: ^{1}H-NMR: 7.67–7.35 (*m*, 10 H); 6.32 (*d*, ^3J(H,F(*E*)) = 39, 1 H). ^{19}F-NMR: −113.5 (*d*, ^3J(F,H(*E*)) = 39). (*E*/*Z*)-**6a**: IR: 3061*s*, 1657*s*, 1501*s*, 1333*s*. ^{13}C-NMR: 133.7–127.1; 124.3 (*d*, ^2J(C=CF(*E*)) = 8); 105.8 (*d*, ^2J(C=CF(*Z*)) = 11). GC-MS: 198 (92.94, M^+), 197 (75.69), 196 (49.41), 40 (100.00).

(E)*- and (*Z*)-1-(2-Fluoro-2-phenylethenyl)-4-methylbenzene* (**6b**). Yield: 1.18 g (66%). (*E*)-**6b**: ^{1}H-NMR: 7.64–7.04 (*m*, 9 H); 6.42 (*d*, ^3J(H,F(*Z*)) = 22, 1 H); 2.29 (*s*, 3 H). ^{19}F-NMR: −97.9 (*d*, ^3J(F,H(*Z*)) = 22). GC-MS: 212 (31.96, M^+), 105 (45.66), 95 (42.47), 91 (42.47), 63 (84.47), 51 (100.00), 50 (50.23). (*Z*)-**6b**: ^{1}H-NMR 7.64–7.04 (*m*, 9 H); 6.28 (*d*, ^3J(H,F(*E*) = 42), 1 H); 2.36 (*s*, 3 H). ^{19}F-NMR: −117.1 (*d*, ^3J(F,H(*E*) = 42)). GC-MS: 212 (100.00, M^+), 197 (72.94), 196 (85.10), 183 (14.71). (*E*/*Z*)-**6b**: IR: 3060*s*, 1657*s*, 1514*s*, 1333*s*. ^{13}C-NMR: 159.1 (*s*); 156.7 (*d*, ^1J(C,F) = 257); 137.2–128.1, 124.2 (*d*, ^2J(C=CF(*E*)) = 8); 105.8 (*d*, ^2J(C=CF(*Z*)) = 10); 21.3 (*s*), 21.1 (*s*).

(E)*- and (*Z*)-1-(2-Fluoro-2-phenylethenyl)-4-methoxybenzene* (**6c**). Yield: 1.38 g (76%). (*E*)-**6c**: ^{1}H-NMR: 7.61–6.88 (*m*, 9 H); 6.40 (*d*, ^3J(H,F(7)) = 22, 1 H); 3.74 (*s*, 3 H). ^{19}F-NMR: −99.2 (*d*, ^3J(F,H(*Z*)) = 22). (*Z*)-**6c**: ^{1}H-NMR: 7.61–6.88 (*m*, 9 H); 6.25 (*d*, ^3J(H,F(*E*)) = 42, 1 H); 3.79 (*s*, 3 H). ^{19}F-NMR: −119.2 (*d*, ^3J(F,H(*E*)) = 42). (*E*/*Z*)-**6c**: IR: 3061*m*, 1684*m*, 1512*s*, 1300*s*. ^{13}C-NMR: 158.8 (*s*), 155.9 (*d*, ^1J(C,F) = 255); 133.2–124.2; 123.8 (*d*, ^2J(C=CF(*E*)) = 8); 105.4 (*d*, ^2J(C=CF(*Z*)) = 11); 55.2 (*s*). GC-MS: 228 (100.00, M^+), 213 (40.31), 183 (23.44), 165 (37.19).

(E)*- and (*Z*)-1-Chloro-4-(2-fluoro-2-phenylethenyl)benzene* (**6d**). Yield: 1.21 g (65%). (*E*)-**6d**: ^{1}H-NMR: 7.60–7.28 (*m*, 9 H); 6.30 (*d*, ^3J(H,F(*Z*)) = 22, 1 H). ^{19}F-NMR: −95.1 (*d*, ^3J(F,H(*Z*)) = 22). (*Z*)-**6d**: ^{1}H-NMR: 7.60–7.28 (*m*, 9 H); 6.20 (*d*, ^3J(H,F(*E*)) = 39, 1 H). ^{19}F-NMR: −115.3 (*d*, ^3J(F,H(*E*)) = 39). (*E*/*Z*)-**6d**: IR: 3072*m*, 1653*s*, 1496*s*, 1334*m*. ^{13}C-NMR: 157.5 (*d*, ^1J(C,F) = 259); 132.9–128.2; 124.3 (*d*, ^2J(C=CF(*E*)) = 8); 104.7 (*d*, ^2J(C=CF(*Z*)) = 10). GC-MS: 232 (16.79, M^+), 229 (15.63), 228 (100.00), 213 (36.34), 165 (39.53).

(E)*- and (*Z*)-1-(2-Fluoro-2-phenylethenyl)-4-nitroethene* (**6e**). Yield: 65% (^{19}F-NMR). (*E*)-**6e**: ^{19}F-NMR: −89.4 (*d*, ^3J(F,H(*Z*)) = 22). (*Z*)-**6e**: ^{19}F-NMR: −110.9 (*d*, ^3J(F,H(trans)) = 39). (*E*/*Z*)-**6e**: IR: 3085*m*, 1654*s*, 1598*s*, 1344*s*. GC-MS: 243 (2.31, M^+), 105 (22.76), 44 (48.13).

(E)*- and (*Z*)-1-(2-Fluoro-2-phenylethenyl)-2-(trifluoromethyl)benzene* (**6f**). Yield: 1.59 g (74%). (*E*)-**6f**: ^{1}H-NMR: 8.00–7.13 (*m*, 9 H); 6.35 (*d*, ^3J(H,F(*Z*)) = 20, 1 H). ^{19}F-NMR: −96.3 (*d*, ^3J(F,H(*Z*)) = 20); −60.9 (*s*). GC-MS: 266 (81.44, M^+), 245 (22.29), 197 (71.13), 196 (100.00). (*Z*)-**6f**: ^{1}H-NMR: 8.00–7.13 (*m*, 9 H); 6.65 (*d*, ^3J(H,F(*E*)) = 37, 1 H). ^{19}F-NMR: −114.2 (*d*, ^3J(F,H(*E*)) = 37); −59.4 (*s*). (*E*/*Z*)-**6f**: IR: 3089*m*, 1654*s*, 1498*s*, 1316*s*. ^{13}C-NMR: 158.3 (*d*, ^1J(C,F) = 261); 157.3 (*s*); 133.1–125.9; 124.8 (*d*, ^2J(C=CF(*E*)) = 8); 101.1 (*d*, ^2J(C=CF(*Z*)) = 10). GC-MS: 266 (80.86, M^+), 245 (21.89), 197 (71.77), 196 (100.00). HR-MS: Calc. 266.0719; found: (*E*)-**6f**: 266.0699; (*Z*)-**6f**: 266.0692.

(E)*- and (*Z*)-(2-Cyclohexyl-1-fluoroethenyl)benzene* (**6g**). Yield: 1.18 g (72%). (*E*)-**6g**: ^{1}H-NMR: 7.50–7.26 (*m*, 5 H); 5.25 (*dd*, ^3J(H,F(*Z*)) = 22, ^3J(H,H) = 11, 1 H); 2.30–2.23 (*m*, 1 H); 1.76–1.11 (*m*, 10 H). ^{19}F-NMR: −102.4 (*d*, ^3J(F,H(*Z*)) = 22). GC-MS: 204 (32.16, M^+), 147 (33.73), 146 (38.43), 122 (100.00). (*Z*)-**6g**: ^{1}H-NMR: 7.50–7.26 (*m*, 5 H); 5.27 (*dd*, ^3J(H,F(*E*)) = 39, ^3J(H,H) = 9, 1 H); 2.70–2.60 (*m*, 1 H); 1.76–1.11 (*m*, 10 H). ^{19}F-NMR: −121.0 (*d*, ^3J(F,H(*E*)) = 39). (*E*/*Z*)-**6g**: IR: 3062*m*, 1653*s*, 1448*s*. ^{13}C-NMR: 157.1 (*s*), 155.8 (*d*, ^1J(C,F) = 240); 133.2–127.5; 123.9 (*d*, ^2J(C,F(*E*)) = 7); 35.3–25.7. GC-MS: 204 (6.22, M^+), 123 (26.78), 122 (100.00), 67 (23.43). HR-MS: Calc.: 204.1314; found: (*E*/*Z*)-**6g**: 204.1334/204.1342.

(E)*- and (*Z*)-1-(2-Fluoro-2-phenylethenyl)-3,4-dimethoxybenzene.* Yield: 1.43 g (69%). (*E*)-**6h**: ^{1}H-NMR: 7.65–7.15 (*m*, 5 H); 6.90–6.60 (*m*, 3 H); 6.40 (*d*, ^3J(H,F(*Z*)) = 22, 1 H); 3.93 (*s*, 3 H); 3.90 (*s*, 3 H). ^{19}F-NMR: −99.3 (*d*, ^3J(F,H(*Z*)) = 22). (*Z*)-**6h**: ^{1}H-NMR: 7.65–7.15 (*m*, 5 H); 6.90–6.60 (*m*, 3 H); 6.25 (*d*, ^3J(H,F(*E*)) =

40); 3.85 (*s*, 3 H); 3.60 (*s*, 3 H). ^{19}F-NMR: −118.7 (*d*, ^{3}J(F,H(*E*)) = 40). (*E*/*Z*)-**6h**: IR: 3060*m*, 1650*m*, 1590*s*, 1450*s*. ^{13}C-NMR: 160.3–157.2; 150.1 (*d*, ^{1}J(C,F) = 269); 133.6–123.9; 115.4–98.2; 55.5 (*s*); 55.4 (*s*); 55.3 (*s*); 55.2 (*s*); GC-MS: 258 (100.00, M^+), 243 (18.0), 195 (38.0).

*(*E*)- and (*Z*)-(1-Fluoro-2-methyl-2-phenylethenyl)benzene* (**6i**). Yield: 0.84 g (50%). (*E*)-**6i**: ^{1}H-NMR: 7.49–7.18 (*m*, 5 H); 2.11 (*d*, ^{4}J(H,F(*Z*)) = 4, 3 H). ^{19}F-NMR: −102.7 (*q*). (*Z*)-**6i**: ^{1}H-NMR: 7.49–7.18 (*m*, 5 H); 2.07 (*d*, ^{4}J(H,F(*E*)) = 2, 3 H). ^{19}F-NMR: −105.5. (*E*/*Z*)-**6i**: IR: 3065*m*, 1664*m*, 1558*m*, 1257*m*. ^{13}C-NMR: 158.0 (*d*, ^{1}J(C,F) = 269); 128.8–127.1; 18.5 (*s*). GC-MS: 212 (100.00, M^+), 197 (42.4), 133 (14.4).

(1-Fluoro-2,2-diphenylethenyl)benzene (**6j**). Yield: 1.05 g (48%). ^{1}H-NMR: 7.73–7.71 (*m*, 5 H); 7.51–7.47 (*m*, 5 H); 7.40–7.37 (*m*, 5 H). ^{13}C-NMR: 137.5–127.8. ^{19}F-NMR: −103.5 (*s*). GC-MS: 274 (100.00, M^+), 182 (22.6), 105 (44.8), 77 (22.4); IR: 3086*m*, 1599*m*, 1261*m*.

(1-Fluoro-2,2-dimethylethenyl)benzene (**6k**). Yield: 50% (^{19}F-NMR). ^{19}F-NMR: −106.3.

[1-Fluoro-2,2-bis(trideuteromethyl)ethenyl]benzene (**6l**). Yield: 52% (^{19}F-NMR). ^{19}F-NMR: −107.5.

*(*E*)- and (*Z*)-1-Fluoro-(2-ethyl-2-methylethenyl)benzene* (**6m**). Yield: 47% (^{19}F-NMR). ^{19}F-NMR: −107.8; −104.3.

(Cyclohexylidene)fluoromethylbenzene. Yield: 54% (^{19}F-NMR). ^{19}F-NMR: −109.4.

*Dependence of the Configuration of (*E/Z*)-***6a*** and (*E/Z*)-***6i*** on Metal Ion and/or Cosolvent as Described by Reaction of the Anion Derived from* ***2*** *with LDA in THF/HMPT and PhCHO.* A soln. of 2.0 mmol (0.49 g) of **2**, 2.0 mmol (0.39 ml) of hexamethylphosphoric triamide (HMPT), and 6 ml of dry THF was cooled and stirred at −78°, as 3.3 mmol (2.2 ml) of a 1.5M cyclohexane soln. of LDA mono(tetrahydrofuran) was added dropwise *via* syringe. The resulting bright yellow soln. was stirred at −78° for 20 min, and then 3.0 mmol (0.32 g) of freshly distilled PhCHO was added dropwise *via* syringe. The resulting mixture was stirred at −78° for 1 h and then allowed to warm to r.t. during 4 h and stirred at that temp. overnight to obtain 84% yield (^{19}F-NMR) of (*E*)- and (*Z*)-**6a**. The (*E*/*Z*)-ratio of **6a**, determined by the integration of the F signals in the ^{19}F-NMR spectrum, was 24 : 76.

*Dependence of the Configuration of (*E/Z*)-***6i*** on Solvent and Base as Described by Reaction of the Anion Derived from* ***2*** *with* t-*BuOK in CH_2Cl_2 and PhC(O)Me.* A soln. of 6 ml of dry THF and 2.0 mmol (0.22 g) of *t*-BuOK was cooled and stirred at −78°, as 2.0 mmol (0.49 g) of **2** was added dropwise *via* syringe. The resulting bright yellow soln. was stirred at −78° for 20 min, and then 2.0 mmol (0.24 g) of freshly distilled PhC(O)Me was added dropwise *via* syringe. The resulting mixture was stirred at −78° for 1 h and then allowed to warm to r.t. over 4 h and stirred at that temp. overnight to obtain 63% yield (^{19}F-NMR) of (*E*)- and (*Z*)-**6i**. The (*E*/*Z*)-ratio of **6i**, determined by the integration of the F signals in the ^{19}F-NMR spectrum, was 66 : 34.

Detection of **3** *as Described for Quenching the Reaction of* **3** *with EtC(O)Cl at −78°.* A soln. of 4.0 mmol (0.99 g) of **2** and 8 ml of dry THF was cooled and stirred at −78°, as 6.0 mmol (4.0 ml) of a 1.5M cyclohexane soln. of LDA mono(tetrahydrofuran) was added dropwise *via* syringe. The resulting bright yellow soln. was stirred at −78° for 20 min, and then 6.0 mmol (0.55 g) of freshly distilled EtC(O)Cl was added dropwise *via* syringe. The resulting mixture was stirred at −78° for 1 h and then allowed to warm to r.t. over 4 h and stirred at that temp. overnight. ^{19}F-NMR Analysis of the reaction mixture is consistent with the formation of $(EtO)_2P(O)CF\{C(O)Et\}Ph$ at −170.2 ppm (*d*, *J*(F,C,P) = 76).

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