Electrolytic Reactions of Fluoroorganic Compounds. 14.[1] Regioselective Anodic Methoxylation of *N*-(Fluoroethyl)amines. Preparation of Highly Useful Fluoroalkylated Building Blocks

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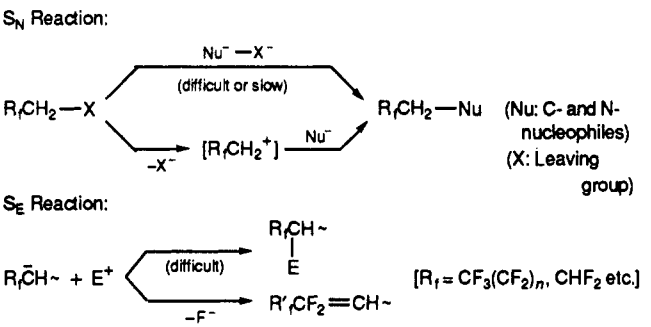
Anodic methoxylation of various types of *N*-(fluoroethyl)amines, $ArRNCH_2R_f$ (R_f = CF_3, CHF_2, CH_2F, etc.) has been systematically studied and it was found that a methoxy group was exclusively or preferentially introduced into the position α to the fluoromethyl (R_f) group, depending on the R_f and R groups. The effect of the R_f group on the promotion of the anodic α-methoxylation decreased in the order CF_3, CHF_2, and CH_2F. This remarkable promotion effect and unique regioselectivity can be explained mainly in terms of the α-CH kinetic acidities of the cation radicals formed by one-electron oxidation of the amines. The α-methoxylated products are highly useful precursors for the construction of carbon–carbon bonds α to the trifluoromethyl and difluoromethyl groups, which is difficult by other methods.

Introduction

Fluoroorganic compounds have unique chemical and physical properties and recently much interest has been paid to partially fluorinated compounds by those in the fields of material science and medicinal chemistry.[2] However, methods for the synthesis of these compounds are quite limited.[3] For example, either nucleophilic or electrophilic substitution (Scheme 1) at the position α to a perfluoroalkyl group generally occurs with difficulty.[4] In the former case, the problem arises from the strong electron-withdrawing effect of the perfluoroalkyl group[5] and in the latter is due to the extremly facile defluorination of anionic intermediates that occurs prior to trapping them with electrophiles.[6] Much effort has been expended to circumvent these problems and to achieve such substitutions. For example, since 1,1-dihydroperfluoroalkyl halides do not readily undergo nucleophilic substitution,[7]

Scheme 1



studies have been conducted in which halogen leaving groups X were replaced by better leaving groups, such as tosylate, mesylate, *o*-nitrobenzenesulfonate.[8] Their nucleophilic substitution with sulfur nucleophiles proceeds quite well. However, the reactions with nitrogen and oxygen nucleophiles result in unsatisfactory yields. Particularly, substitution with carbon nucleophiles is difficult, even when very reactive triflates or triclates are used under severe conditions.[9] Recently, 1,1-dihydroperfluoroalkylating reagents have been developed;[10] however such reagents are costly and require multiple-step syntheses. Thus, the achievement of this desired substitution, and in particular the formation of a carbon–carbon bond at the α-position, remains an important goal of modern organofluorine chemistry.

Electrochemical reactions have recently been shown to be powerful tools in organic synthesis.[11] With regard to fluoroorganic compounds, electroperfluorination has been

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well developed[12,13] and electrolytic trifluoromethylation has been extensively studied.[14] Although anodic substitution is a known characteristic of certain electrochemical reactions, few results pertaining to the electrolytic substitution of trifluoromethylated compounds have been reported.[15]

We have approached these problems by using electrochemical techniques.[16] For example, we have found that anodic methoxylation of *N*-alkyl-*N*-(2,2,2-trifluoroethyl)anilines places the methoxy group in the α-position exclusively, and the regioselectivity is reversed relative to that of the corresponding nonfluorinated case.[16c] This preliminary result suggests that anodic oxidation should be an efficient method for the generation of electronegatively-substituted carbocations.[5c] Therefore, it is important to clarify the unique effect of fluorine atoms on this novel, regioselective anodic methoxylation, in terms of both mechanism and synthetic potential.

In this work, we have systematically examined the anodic methoxylation of various types of *N*-(fluoroethyl)anilines and *N*-aryl-*N*-(fluoroethyl)amines in order to determine the full scope of this reaction. In addition, the oxidation potentials of these fluorinated amines were measured in order to investigate the effect of fluorine atoms. The oxidation potentials of only a limited number of fluoroorganic compounds have been reported to date, outside of our work[16] and that of Becker *et al.*[17]

Results and Discussion

Preparation of *N*-(Fluoroethyl)amines. The starting *N*-(fluoroethyl)amines **4**, **5**, and **7** were prepared in good yields by fluoroacetylation of the corresponding amines or lithium amides, followed by reduction with a borane–dimethyl sulfide complex, as shown in Scheme 2. Although it was reported that $NaAlH_2(OCH_2CH_2OMe)$ was effective for the reduction of *N*-trifluoroacetanilide to *N*-(2,2,2-trifluoroethyl)aniline,[19] it primarily caused reductive cleavage of a carbon–nitrogen bond of **1**. Even though the borane–dimethyl sulfide complex was used, *N*,*N*-diphenyltrifluoroacetamide (**1e**) provided the corresponding trifluoroethyl derivative **4e** in low yield, due to the competing reductive cleavage of a **1e** carbon–nitrogen bond. Monofluoroethylamines **6** were prepared directly by the reaction of lithium amides with 1-bromo-2-fluoroethane.

Scheme 2

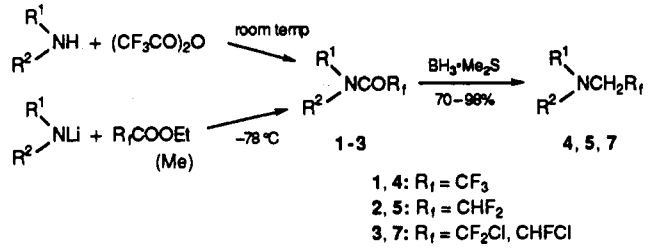
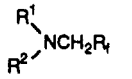
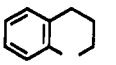


Table 1. Oxidation Potentials (Half-Peak Potentials, $E^{ox}_{p1/2}$) of *N*-(Fluoroethyl)amines[a]



amine no.	R^1	R^2	R_f	$E^{ox}_{p1/2}$ (V vs SCE)
4b	C_6H_5	CH_3CH_2	CF_3	+0.96
4c	*m*-$CH_3C_6H_4$	CH_3CH_2	CF_3	+0.97
4d	*p*-$CH_3C_6H_4$	CH_3CH_2	CF_3	+0.95
4f	α-naphthyl	CH_3CH_2	CF_3	+1.02
4g			CF_3	+0.87
7a	C_6H_5	CH_3CH_2	CF_2Cl	+1.00
7b	C_6H_5	CH_3	CHFCl	+0.92
5b	C_6H_5	CH_3CH_2	CHF_2	+0.88
5c	*m*-$CH_3C_6H_4$	CH_3CH_2	CHF_2	+0.82
6b	C_6H_5	CH_3CH_2	CH_2F	+0.76
	C_6H_5	CH_3CH_2	CH_3	+0.64

[a] 2 mmol of amine in 0.1 M Et_4NOTs–CH_3CN. Sweep rate: 100 mV/s.

Oxidation Potentials of *N*-(Fluoroethyl)amines. In order to investigate the effect of fluoroalkyl groups on the oxidation potentials of amines, the anodic peak potentials of **4**–**7** were measured by cyclic voltammetry, using a glassy carbon anode in anhydrous acetonitrile. These amines showed irreversible multiple anodic waves. The first peak potentials $E^{ox}_{p1/2}$ are summarized in Table 1.

The fluorinated amines were found to be oxidized at a more positive potential than the corresponding nonfluorinated amines. This is due to the electron-withdrawing effect of fluoroalkyl groups.

As shown in Figure 1, a good linear correlation of the oxidation potentials $E^{ox}_{p1/2}$ with Taft's σ^* values for the fluoromethyl groups was obtained. This clearly indicates that the polar effect of the fluoroalkyl group plays a significant role in the electron-transfer step from the amine to the anode. Namely, the oxidation potential increases linearly as the number of fluorine atoms on the fluoroalkyl group increases.

Anodic Methoxylation of *N*-(Fluoroethyl)amines. Anodic methoxylation of various *N*-(2,2,2-trifluoroethyl)amines **4** was carried out at a carbon anode in an alkaline methanol solution, using an undivided cell. A

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(15) After we published our preliminary results of this work,[16c] some papers were reported on electrochemical trifluoromethylation of aldehydes and ketones: (a) Sibille, S.; Mcharex, S.; Perichon, J. *Tetrahedron* **1989**, *45*, 1423. (b) Shono, T.; Ishifune, M.; Okada, T.; Kashimura, S. *J. Org. Chem.* **1991**, *56*, 2. (c) Shono, T.; Kise, N.; Oka, H. *Tetrahedron Lett.* **1991**, *45*, 6567. (d) Medebielle, M.; Pinson, J.; Saveant, J.-M. *J. Am. Chem. Soc.* **1991**, *113*, 6872.

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(18) *N*-Alkyl-*N*-(2,2,2-trifluoroethyl)-*m*-anisidine has been prepared similarly by using diborane: Johson, T.; Subramanian, R. *J. Org. Chem.* **1986**, *51*, 5041.

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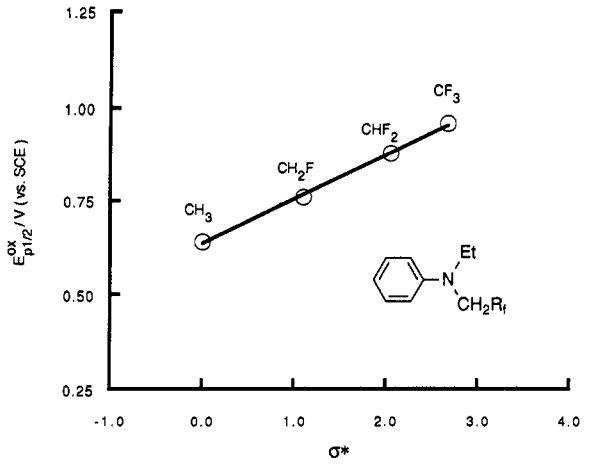
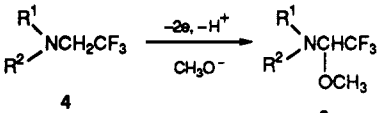
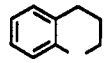


Figure 1. Relationship between oxidation potentials ($E^{ox}_{p1/2}$) and substituent constants (σ^*).

Table 2. Anodic Methoxylation of *N*-(Trifluoroethyl)amines



4 8

run	no.	R^1	R^2	charge passed (F/mol)	product yield (%)
1	**4a**	C_6H_5	CH_3	3.8	(**8a**) 71[a]
2	**4b**	C_6H_5	CH_3CH_2	4.9	(**8b**) 85
3	**4c**	*m*-$CH_3C_6H_4$	CH_3CH_2	5.2	(**8c**) 71
4	**4d**	*p*-$CH_3C_6H_4$	CH_3CH_2	3.5	(**8d**) 78
5	**4e**	C_6H_5	C_6H_5	7.8	(**8e**) 81
6	**4f**	α-naphthyl	CH_3CH_2	29.1	(**8f**) 21
7	**4g**			2.7	(**8g**) 36[b]

[a] $C_6H_5NHCH_2CF_3$ (29%) was formed. [b] **8h** (50%) was obtained after isolation.

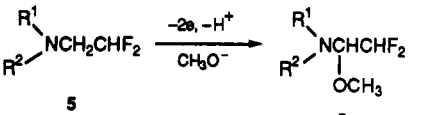
constant current was passed until the starting amines were consumed. The results are summarized in Table 2.

As shown in Table 2, *N*-alkyl-*N*-(2,2,2-trifluoroethyl)anilines **4a–d** and *N*-(2,2,2-trifluoroethyl)diphenylamine (**4e**) underwent smooth anodic methoxylation to provide the α-methoxylated products **8** in good yields. The methoxy group was preferentially introduced into the position α to the trifluoromethyl group of **4**, as measured by ^1H and ^{19}F NMR spectroscopy. Thus, *N*-ethylaniline (**4b**) gave only one isomer of α-methoxylated product **8b**. It is quite interesting that the anodic methoxylation occurred predominantly at the 2,2,2-trifluoroethyl group of *N*-methylaniline (**4a**),[20] while such anodic methoxylation is known to occur exclusively at the methyl group of nonfluorinated *N*-ethyl-*N*-methylaniline.[21] Thus, the trifluoromethyl group dramatically changed the regioselectivity of such anodic methoxylations. Furthermore, it should be recognized that the highly regioselective methoxylation took place even in the case of the *p*-tolyl derivative **4d**, which has a methyl group that should be easily substituted, anodically.[22] Thus, the trifluoromethyl group strongly promotes anodic substitution at its α-position.

(20) In this case, the methoxylation seems to partly occur at the methyl group since the demethylation product due to hydrolysis was formed in 29%.

(21) Shono, T.; Matsumura, Y.; Inoue, K.; Ohmizu, H.; Kashimura, S. *J. Am. Chem. Soc.* **1982**, *104*, 5753.

Table 3. Anodic Methoxylation of Difluoroamines



5 9

run	no.	R^1	R^2	charge passed (F/mol)	product yield (%)
1	**5a**	C_6H_5	CH_3	3.3	(**9a**) 19[a]
2	**5b**	C_6H_5	CH_3CH_2	4.5	(**9b**) 91
3	**5c**	*m*-$CH_3C_6H_4$	CH_3CH_2	3.6	(**9c**) 75
4	**5d**	*p*-$CH_3C_6H_4$	CH_3CH_2	3.5	(**9d**) 87
5	**5e**	C_6H_5	C_6H_5	3.4	(**9e**) 60

[a] $C_6H_5NHCH_2CHF_2$ (48%) was formed [*m/e* 157 (M^+), 106 ($M^+ - CHF_2$), 77 (Ph^+)].

Next, the anodic methoxylation was attempted using the more complicated *N*-(2,2,2-trifluoroethyl)amine derivatives **4f** and **4g**. The α-naphthylamine derivative **4f** also provided an α-methoxylated product although the yield was low. In the case of fused cyclic amine **4g**, the desired α-methoxylated product **8g** was obtained in reasonable yield, although ring substitution took place preferentially.[23] In contrast, it has been reported that anodic methoxylation of nonfluorinated *N*-methyltetrahydroquinoline was unsuccessful. In this case, methoxylation took place at the methyl groups preferentially, and at the ring only to a small extent. However, the resulting products were so unstable as to be difficult to isolate. Thus, *N*-(methoxymethyl)tetrahydroquinoline was not obtained at all.[21] Again, our results suggest that the trifluoromethyl group stabilizes *N,O*-acetals.

Although anodic ring substitution occurs much more easily than side-chain substitution in general,[16e,21] it is notable that the considerable anodic methoxylation of **4g** took place at the trifluoroethyl side-chain group. Here again, it was shown that trifluoromethyl group promoted anodic α-methoxylation.

Next, anodic methoxylation of difluoroethylamines **5** was similarly attempted. In these cases, less electricity was required for consumption of the starting amines **5**.

As shown in Table 3, the difluoro derivatives **5** also gave α-methoxylated products **9** in high yields, and high regioselectivity was observed. However, the *N*-methyl derivative **5a** gave the methoxylated product **9a** in poor yield and carbon–nitrogen bond cleavage occurred preferentially, unlike the case of **4a**. This indicates that the difluoromethyl group promotes the α-methoxylation less than the trifluoromethyl group and that *N*-methylaniline and *N*-ethylaniline derivatives behave differently in the anodic reaction.[24]

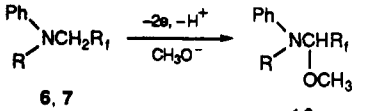
In order to investigate both the scope and the limitations of this novel regioselective anodic reaction, the anodic methoxylation of monofluoro- and chlorofluoroethylamines (anilines) **6** and **7** was examined. As shown in Table 4 (runs 1–3), the amount of electricity required for the electrolysis of **6** was less than that for **5**. It is interesting

(22) We have found that phenyl 2,2,2-trifluoroethyl sulfide undergoes anodic methoxylation highly selectively while the *p*-tolyl sulfide derivative does not.[16h]

(23) However, the ring-substituted product is very unstable and when its isolation was attempted by distillation, elimination of methanol took place and only the dihydroquinoline derivative **8h** was obtained (see Table 2, run 7).

(24) We have also found that the anodic behavior of *N*-methyl- and *N*-ethylaniline derivatives having an electron-withdrawing cyano group at the α-position are different: Fuchigami, T.; Fujita, Y.; Nonaka, T. *J. Electroanal. Chem.* **1990**, *284*, 115.

Table 4. Anodic Methoxylation of *N*-(Monofluoroethyl)- and *N*-(Chlorofluoroethyl)anilines



6, 7 10

run	no.	R	R_f	charge passed (F/mol)	yield (%) 10	yield (%) others
1	**6a**	CH_3	CH_2F	2.8	0	$PhN(CH_2OCH_3)CH_2CH_2F$ (**10a'**) (84)
2	**6b**	CH_3CH_2	CH_2F	3.0	(**10b**) 45	$PhNHCH_2CH_2F$ (trace)[a]
3	**7a**	CH_3CH_2	CF_2Cl	5.0	0	recovery (45)
4	**7b**	CH_3	CHFCl	5.0	0	$PhNHCH_2CHFCl$ (6)[b] recovery (3)
5	**7c**	CH_3CH_2	CHFCl	5.0	0	$PhNHCH_2CH_3$ (9) recovery (45)

[a] Detected by MS: *m/e* 139 (M^+), 77 (Ph^+). [b] Confirmed by MS: *m/e* 175 ($M^+ + 2$), 173 (M^+), 106 ($M^+ - CHFCl$).

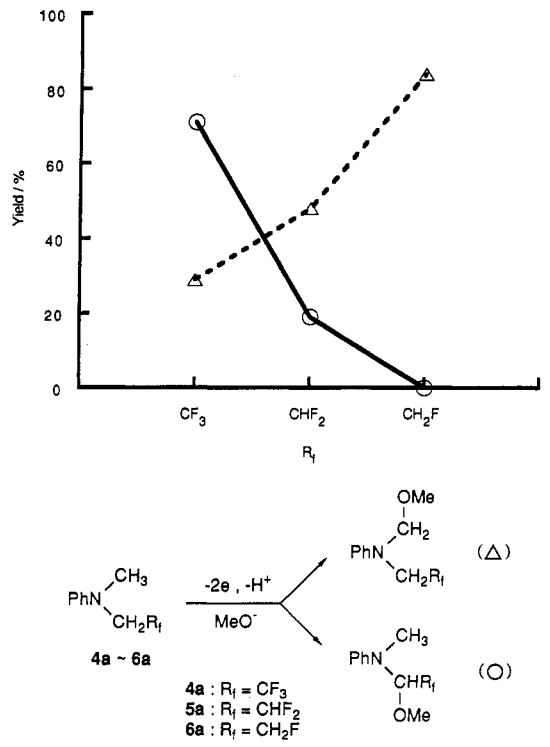


Figure 2. Relationships between yields of the methoxylated products and R_f groups in the anodic methoxylation of *N*-(fluoroethyl)-*N*-methylanilines.

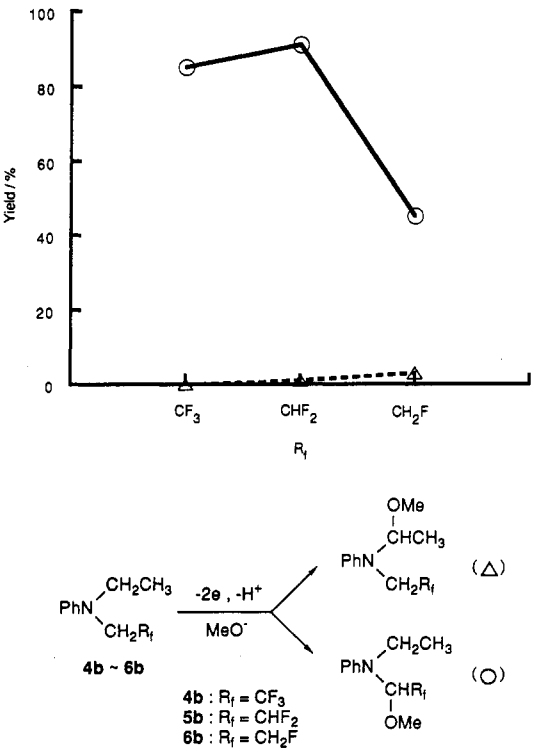


Figure 3. Relationships between yields of the methoxylated products and R_f groups in the anodic methoxylation of *N*-ethyl-*N*-(fluoroethyl)anilines.

that even the monofluoromethyl group promoted anodic α-methoxylation, as observed in the case of *N*-ethyl-*N*-(2-fluoroethyl)aniline (**6b**), although the yield was unsatisfactory. On the other hand, methoxylation occurred exclusively at the methyl group of the *N*-methylaniline derivative **6a**. This regioselectivity is similar to that observed in the anodic methoxylation of nonfluorinated *N*-ethyl-*N*-methylaniline.[21] Thus the *N*-methyl derivative behaves differently, anodically, than the *N*-ethyl compound.

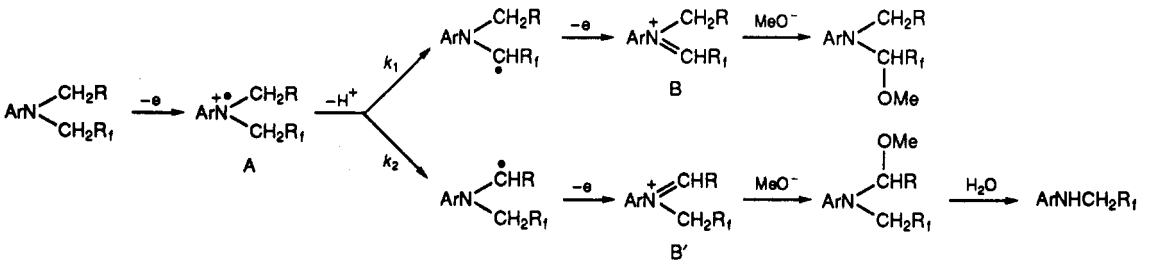
In contrast, chlorinated fluoroanilines **7** did not exhibit such a remarkable promotion effect and complicated product mixtures were formed. At present, it is not clear why chlorine so drastically inhibited such α-methoxylation.

Effect of Fluoromethyl Groups on the Regioselectivity of the Anodic Methoxylation. As shown in Figure 2, the regioselectivity of the anodic methoxylation of fluorinated *N*-methylanilines greatly depended on the nature of the fluoromethyl group. Namely, as the number of fluorine atoms decreased, the promotion effect on the methoxylation drastically decreased. It is noteworthy that the regioselectivity of *N*-(trifluoroethyl)aniline **4a** is completely reversed relative to that of *N*-(monofluoroethyl)aniline **6a**. On the other hand, the regioselectivity in the methoxylation of the corresponding *N*-ethylanilines was only slightly affected by fluoromethyl groups, as shown in Figure 3. Anodic methoxylation occurred predominantly at the fluoroethyl group, although a monofluoromethyl group caused an appreciable decrease in the yield. Thus, the order of the promotion effect on the methoxylation was $CF_3 > CHF_2 >> CH_2F$.

Reaction Mechanism. To elucidate the reaction mechanism of the anodic methoxylation, current–potential curves of the fluorinated amines were measured. Figure 4 shows a typical example of a series of *N*-ethyl-*N*-(fluoroethyl)-*m*-toluidines, **4c**, **5c**, and **6c**.

A cathodic shift was observed in the curves when **5c** and **6c** were added to the electrolytic solution, but such a cathodic shift was not observed in the case of **4c**, because of its higher oxidation potential. The cathodic shift of **6c**

Scheme 3



$R_f = CF_3$: $k_1 >> k_2$ (R = Me, H)
CHF_2: $k_1 >> k_2$ (R = Me); $k_1 \leq k_2$ (R = H)
CH_2F: $k_1 \geq k_2$ (R = Me); $k_1 << k_2$ (R = H)

was larger than that of **5c**. Furthermore, the electricity required for the electrolysis decreased in going from trifluoroethyl derivatives **4** to monofluoro derivatives **6**. This tendency is consistent with the order of the oxidation potentials.

Thus, the reaction appears to take place primarily by direct oxidation of the substrate amines. In addition, since no benzylic substitution was observed in the electrolysis of *m*- and *p*-tolyl derivatives **4c**, **4d**, **5c**, and **5d**, another mechanism, perhaps the oxidation initiated by anodically generated methoxy radicals, is not likely, although the oxidation of methanol takes place simultaneously during the electrolysis. In support of this hypothesis, the photochemical generation of alkoxy radicals, such as *tert*-butoxy radicals, from *tert*-butyl peroxide in the presence of *p*-toluidine derivative **4d** did not result in the formation of products which were *tert*-butoxylated at either the fluorinated or the nonfluorinated ethyl group. Instead, many complicated products having high molecular weight were formed together with small amounts of dimerized and *tert*-butoxylated products derived from benzylic radicals which were detected by mass spectrometry.[25]

Given these results, anodic methoxylation seems to proceed *via* electrogenerated cationic species as is seen with the nonfluorinated amines, carbamates, and amides (Scheme 3).[26] However, the regioselectivity of this anodic methoxylation does not seem to be governed by the stability of the cationic intermediates **B** and **B'** (it is not thermodynamically controlled) since the main products were formed *via* the less stable intermediates **B**.

With *N*-ethyl derivatives, the methoxylation did not occur at the ethyl group but exclusively at the α-carbon adjacent to a fluoroalkyl group (R_f), regardless of the kind of group. This can be explained in terms of facilitation of deprotonation of **A** by the electron-withdrawing R_f groups (i.e. kinetic acidity control).[27] Namely, as shown in Figure 5, the kinetic acidity of the α protons, H_2, should increase due to the electron-withdrawing R_f group, while that of H_b decreases due to the electron-donating methyl group. Then, the large difference in the kinetic acidities of H_a and H_b leads to the elimination of H_a exclusively (R_f = CF_3, CHF_2) or predominantly (R_f = CH_2F).

On the other hand, the trend in the regioselectivity in the *N*-methyl derivatives appears to be different from that

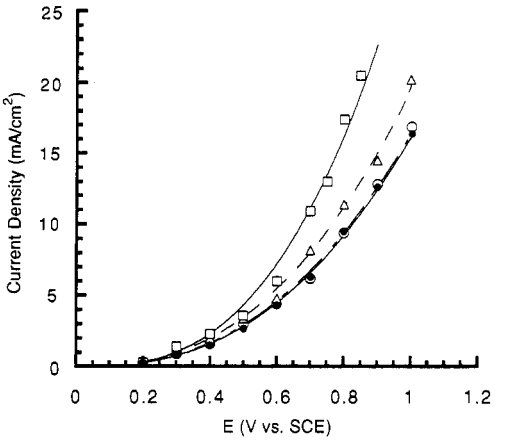


Figure 4. Current–potential curves: 0.34 M KOH–CH_3OH solution (●); in the presence of 0.29 M of *m*-$MeC_6H_4N(CH_2R_f)Et$ [**4c** (R_f = CF_3), (○), **5c** (R_f = CHF_2) (△), **6c** (R_f = CH_2F) (□)].

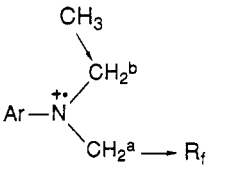


Figure 5. Kinetic acidity of α-protons.

observed in the *N*-ethyl derivatives.[28] However, the regioselectivity can also be explained by considering the difference in the α-CH kinetic acidities (methyl protons *vs* methylene protons) of **A** as shown in Scheme 3.[28]

Thus, it can be concluded that the cation radical kinetic acidity contributes greatly to the regioselectivity of the anodic methoxylation in strongly alkaline media.

Synthesis of Fluoroorganic Nitrogen Compounds Using α-Methoxylated Amines. Preparation of α-Tri-

(25) The dimer seems to be $[CF_3CH_2(C_2H_5)NC_6H_4CH_2]_2$: MS *m/e* 432 ($M^+$), 216 ($^1/_2$ M^+). *tert*-Butoxylated product seems to be t-$BuOCH_2C_6H_4N(C_2H_5)CH_2CF_3$: Ms *m/e* 289 ($M^+$), 216 ($M^+ - t$-BuO), 202 ($M^+ - t$-$BuOCH_2$), 120 ($CH_2C_6H_4NHCH_2^+$).

(26) (a) Weinberg, N. L.; Reddy, T. B. *J. Am. Chem. Soc.* **1968**, *90*, 91. (b) Shono, T.; Hamaguchi, H.; Matsumura, Y. *J. Am. Chem. Soc.* **1975**, *97*, 4264.

(27) (a) Nelsen, S. F.; Ippoliti, J. T. *J. Am. Chem. Soc.* **1986**, *108*, 4879. (b) Xu, W.; Mariano, P. S. *J. Am. Chem. Soc.* **1991**, *113*, 1431. (c) Yoon, V. C.; Mariano, P. S. *Acc. Chem. Res.* **1992**, *25*, 233.

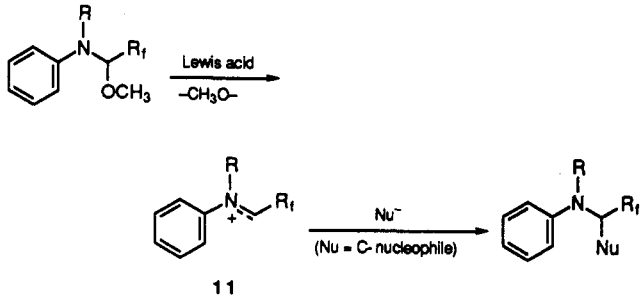
(28) Taking into consideration the proposed mechanisms for characteristic regioselective anodic substitution such as methoxylation of *N,N*-dimethylbenzylamine[29] and cyanation of *N*-ethyl-*N*-methylaniline,[30] the absorption effect of the substrate on the anode which is characteristic of heterogeneous electrochemical reactions, namely deprotonation from cation radical intermediates adsorbed on the anode, may cause such different regioselectivity. So, we have investigated amine–enone single electron transfer (SET) photochemical reactions. It was found that the photoaddition of *N*-methyl- and *N*-ethyl-*N*-(2,2,2-trifluoroethyl)-*p*-toluidines with 3-phenylcyclohex-2-en-1-one took place at the (trifluoroethyl/alkyl) position in (31/14) and (56/0)%, respectively.[31] This regioselectivity resembles that of the anodic methoxylation of **4a** and **4b**. Therefore, the regioselectivity of the anodic methoxylation is not a characteristic feature of the heterogeneous reaction media. However, at present time, it is not clear that there is a possibility of adsorption of the substrate amines and/or their intermediate on the anode in our electrolytic reactions.

(29) Weinberg, N. L.; Brown, E. A. *J. Org. Chem.* **1966**, *31*, 4058.

(30) Andreades, S.; Zahrow, E. W. *J. Am. Chem. Soc.* **1969**, *91*, 4181.

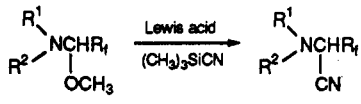
(31) Konno, A.; Fuchigami, T. *Chem. Lett.* **1992**, 2181.

Scheme 4



11

Table 5. Preparation of Fluorinated α-Amino Nitrile



8, 9 12, 13

substrate	R^1	R^2	R_f	acid	yield (%)
8b	Ph	Et	CF_3	$TiCl_4$	(**12b**) 49
8b	Ph	Et	CF_3	$BF_3{\cdot}Et_2O$	(**12b**) 73
8d	*p*-Tol	Et	CF_3	$BF_3{\cdot}Et_2O$	(**12d**) 94
8e	Ph	Ph	CF_3	$BF_3{\cdot}Et_2O$	(**12e**) 71
9b	Ph	Et	CHF_2	$BF_3{\cdot}Et_2O$	(**13b**) 90
9c	*m*-Tol	Et	CHF_2	$BF_3{\cdot}Et_2O$	(**13c**) 92

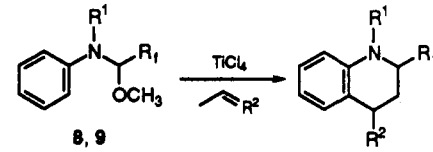
and α-Difluoromethylated α-Aminonitrile. Generally, generation of a carbocation bearing an α-trifluoromethyl group is quite difficult due to its high electronegativity. Since the anodically prepared α-methoxylated trifluoroethylamines have acetal structures, it was expected that Lewis acid-catalyzed elimination of the methoxy group would generate the corresponding carbocation **11**, which should be stabilized by the neighboring nitrogen atom as shown in Scheme 4.

Using cyanosilane as a carbon nucleophile, the substitution of α-methoxylated trifluoroethylamines **8** was first attempted. Cyanation of **8** was carried out in dichloromethane at ca. −78 °C. As shown in Table 5, the reaction in the presence of $TiCl_4$ did not provide the desired α-cyanation product **12** efficiently but resulted in the formation of many byproducts. It was found that the yield could be remarkably increased by using a less active Lewis acid such as $BF_3{\cdot}OEt_2$. Next, we successfully extended this cyanation reaction to difluoroethylamines **9**.

Tri- and difluoromethylated α-amino nitriles **12** and **13** thus obtained should be versatile building blocks and are useful precursors to the corresponding fluorinated α-amino acids, which are currently of biological interest.[2,3d,32]

Preparation of Tri- and Difluoromethylated Tetra- and Dihydroquinoline Derivatives by Cationic Polar Cycloaddition. Although the polar cycloaddition of aryliminium salts has been extensively studied,[33] cycloaddition with polar systems containing nitrogen-stabilized α-tri- and α-difluoromethylated carbocations has not been reported. We attempted the cationic polar cycloaddition of α-methoxylated amines **8** and **9** with nucleophilic unsaturated compounds in the presence of a Lewis acid. The cycloaddition of **8** and **9** with styrenes was successfully carried out in dichloromethane at −78 °C in the presence of $TiCl_4$, to provide the corresponding tri- and difluoromethylated tetrahydroquinoline derivatives **14** and **15**,

Table 6. Preparation of Fluoromethylated Tetrahydroquinoline Derivatives



8, 9 14, 15

substrate	R^1	R^2	R_f	product yield (%)	product trans:cis[a]
8b	Et	Ph	CF_3	(**14b**) 51	(91:9)
8e	Ph	Ph	CF_3	(**14e**) 63	(86:14)
8d	Ph	*p*-Tol	CF_3	(**14d**) 65	(74:26)
9e	Ph	Ph	CHF_2	(**15e**) 77	(67:33)
9d	Ph	*p*-Tol	CHF_2	(**15d**) 86	(64:36)

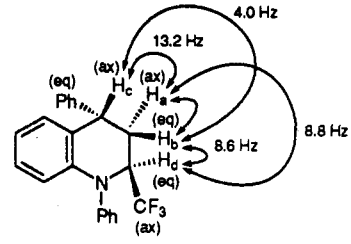
[a] Determined by ^{19}F NMR and ^1H NMR.

respectively, in good yields, as shown in Table 6. The products **14** and **15** seem to consist primarily of the trans isomer,[34] although the cis isomers were observed to a minor extent in the ^{19}F NMR spectra.[36]

Next, the cycloaddition with phenylacetylene was similarly attempted. However, the reaction resulted in a low yield and the formation of many byproducts. It was found that the yields of the desired product **16e** and **17e** were markedly increased by using a less reactive Lewis acid such as $BF_3{\cdot}OEt_2$, as shown in Scheme 5.

Thus, we have shown that anodically prepared α-methoxylated amines are highly useful fluoro building blocks for the construction of carbon–carbon bonds α to fluoroalkyl groups and, in particular, α to trifluoromethyl and difluoromethyl groups. It has been reported that an α-methoxylated compound anodically prepared from *N,N*-dimethylaniline is also a versatile building block. However this methoxylated aniline derivative can be prepared by the reaction with formaldehyde and methanol, although the yield is unsatisfactory.[21] On the contrary, α-fluoro-

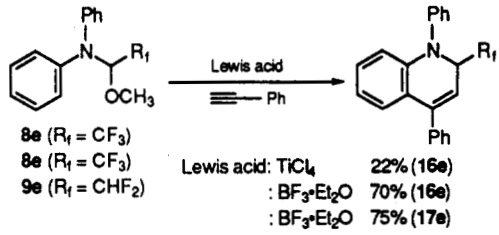
(34) Separation of the trans and cis isomers was unsuccessful. The major component, the trans isomer, was established on the basis of coupling constants of ^1H NMR. For example, the configuration and main conformation of trans **14e** can be as shown as below.[16f] The Karplus relationship cannot be adequately applied to this compound because it has electronegative substituents such as a CF_3 group and a nitrogen atom. However, in consideration of coupling in fused cyclohexane rings,[35] a large $J_{H_cH_a}$ value should be due to trans axial–axial coupling while a small $J_{H_cH_b}$ value seems to be cis axial–equatorial coupling. This indicates that the 4-phenyl group should be equatrial. On the other hand, $J_{H_aH_d}$ and $J_{H_bH_d}$ values are almost equal; therefore these values should be due to axial–equatrial and equatrial–equatrial coupling, respectively. If H_d is axial, the $J_{H_bH_d}$ value should be much larger than that of $J_{H_bH_d}$ as observed in coupling between H_a and H_c. Therefore, H_d must be equatorial; then the CF_3 should be axial. In addition, geminal coupling ($J_{H_aH_b}$) is reasonable as observed in the case of fused cyclohexane rings.[35] Thus, it was concluded that the CF_3 group (axial) and the phenyl group (equatrial) are trans.



14e

(32) Kawada, K.; Tsushima, T. *Chem. Ind.* **1987**, *38*, 164.
(33) Bradsher, C. K. In *Advances in Heterocyclic Chemistry*, Vol. 16; Katritzky, A. R., Bouiton, A. J.; Eds.; Akademic Press: New York, 1974; pp 289–324.
(35) Silverstein, R. M.; Bassler, G. C. *Spectrometric Identification of Organic Compounds*, 2nd ed.; Wiley: New York, 1967; Chapter 4.
(36) However, assignment of ^1H NMR spectra of the cis isomers was unsuccessful due to their weak signals.

Scheme 5



8e ($R_f = CF_3$)
8e ($R_f = CF_3$) Lewis acid: $TiCl_4$ 22% (**16e**)
9e ($R_f = CHF_2$) : $BF_3{\cdot}Et_2O$ 70% (**16e**)
: $BF_3{\cdot}Et_2O$ 75% (**17e**)

alkylated *N,O*-acetals developed in this work are difficult to prepare by other methods.

In summary, this work serves to illustrate that the electrochemical technique is a versatile method for the preparation of α-fluoroalkyl *N,O*-acetals that then permit the introduction of carbon nucleophiles bearing various functional groups into the α-position. Furthermore, we have shown that anodic oxidation is a promising method for the generation of electronegatively-substituted carbocations.

Experimental Section

^1H NMR and ^{19}F NMR spectra were recorded at 60 MHz on Varian EM 360 NMR and Hitachi R-24F NMR spectrometers, respectively. The chemical shifts for ^1H and ^{19}F NMR are given in δ downfield from internal Me_4Si and upfield from external CF_3COOH, respectively. IR spectra were obtained with a Hitachi 295 infrared spectrometer. Mass spectra were obtained with a JEOL JMS-D100 GC-mass spectrometer. High-resolution mass spectra were obtained with a Hitachi M-80B GC-mass spectrometer. Cyclic voltammetric and preparative electrolysis experiments were carried out using a Hokutodenko HA-501 potentiostat/galvanostat equipped with a Hokutodenko HF-201 digital coulombmeter.

***N*-(Fluoroethyl)amines.** *N*-(2,2,2-Trifluoroethyl)amines **4** were prepared by trifluoroacetylation of the corresponding amines with trifluoroacetic anhydride followed by reduction with borane–dimethyl sulfide complex.[16c,18] *N*-(2,2-Difluoroethyl)amines **5** and *N*-(chlorofluoroethyl)amine **7** were similarly prepared by the reaction of lithium amides with the corresponding fluoroacetic acid ester followed by reduction. *N*-(Monofluoroethyl)amines **6** were prepared from lithium amines and 1-bromo-2-fluoroethane.

Purification was performed by distillation under reduced pressure or column chromatography on silica gel using hexane–AcOEt (2:1–20:1).

Typical Procedure for the Preparation of *N*-Methyl-*N*-(2,2,2-trifluoroethyl)amine (4a). After 10.6 mL of borane–dimethyl sulfide complex (90%, 99 mmol) was added dropwise to a stirred solution of *N*-methyl-*N*-(trifluoroacetyl)anilide (45 mmol) in 45 mL of THF at 3 °C, the reaction mixture was heated under reflux in a nitrogen atmosphere for 2 h. Methanol was added slowly to the reaction mixture under cooling in an ice bath until evolution of gas stopped and then a large amount of water was added. The resulting mixture was repeatedly extracted with ether and the extracts were dried (Na_2SO_4). The extracts were concentrated and the remaining oil was distilled under reduced pressure to give pure **4a** in 63% yield: bp 65–67 °C (6 Torr); ^{19}F NMR ($CDCl_3$) δ 7.16 (t, $J_{H,F}$ = 9 Hz); ^1H NMR ($CDCl_3$) δ 2.51 (s, 3 H, CH_3), 3.40 (q, 2 H, CH_2), 6.3–7.3 (m, 5 H, Ph); MS *m/e* 189 (M^+), 174 (M^+ – Me). Anal. Calcd for $C_9H_{10}F_3N$: C, 57.12; H, 5.33; N, 7.41. Found: C, 57.02; H, 5.42; N, 7.38.

***N*-Ethyl-*N*-(2,2,2-trifluoroethyl)aniline (4b):** yield 75%; bp 65–69 °C (6 Torr); ^{19}F NMR ($CDCl_3$) δ 6.90 (t, $J_{H,F}$ = 9 Hz); ^1H NMR ($CDCl_3$) δ 1.10 (t, 3 H, CH_3, *J* = 7 Hz), 3.39 (q, 2 H, CH_2, *J* = 7 Hz), 3.70 (q, 2 H, CH_2CF_3), 6.5–7.4 (m, 5 H, Ph); MS *m/e* 203 (M^+), 188 (M^+ – Me), 139 (M^+ – CF_3), 77 (Ph^+). Anal. Calcd for $C_{10}H_{12}F_3N$: C, 59.09; H, 5.95; N, 6.90. Found: C, 59.28; H, 6.27; N, 7.05.

***N*-Ethyl-*N*-(2,2,2-trifluoroethyl)-*m*-toluidine (4c):** yield 78%; ^{19}F NMR (CCl_4) δ 6.25 (t, $J_{H,F}$ = 9 Hz); ^1H NMR ($CDCl_4$) δ 1.09 (t, 3 H, CH_3, *J* = 7 Hz), 2.27 (s, 3 H, $CH_3C_6H_4$), 3.32 (q, 2 H, CH_2, *J* = 7 Hz), 3.62 (q, 2 H, CH_2CF_3), 6.23–7.10 (m, 4 H, C_6H_4); MS *m/e* 217 (M^+), 202 (M^+ – Me), 148 (M^+ – CF_3). Anal. Calcd for $C_{11}H_{14}F_3N$: C, 60.80; H, 6.50; N, 6.45. Found: C, 60.91; H, 6.45; N, 6.51.

***N*-Ethyl-*N*-(2,2,2-trifluoroethyl)-*p*-toluidine (4d):** yield 83%; ^{19}F NMR (CCl_4) δ 6.67 (t, $J_{H,F}$ = 9 Hz); ^1H NMR (CCl_4) δ 1.11 (t, 3 H, CH_3, *J* = 7 Hz), 2.21 (s, 3 H, $CH_3C_6H_4$), 3.33 (q, 2 H, CH_2, *J* = 7 Hz), 3.65 (q, 2 H, CH_2CF_3), 6.40–7.06 (m, 4 H, C_6H_4); MS *m/e* 217 (M^+), 202 (M^+ – Me), 148 (M^+ – CF_3). Anal. Calcd for $C_{11}H_{14}F_3N$: C, 60.80; H, 6.50; N, 6.45. Found: C, 60.60; H, 6.20; N, 6.55.

***N,N*-Diphenyl-*N*-(2,2,2-trifluoroethyl)amine (4e):** yield 49%; ^{19}F NMR ($CDCl_3$) δ 8.67 (t, $J_{H,F}$ = 9 Hz); ^1H NMR ($CDCl_3$) δ 4.16 (q, 2 H, CH_2), 6.7–7.4 (m, 10 H, Ph); MS *m/e* 251 (M^+), 182 (M^+ – CF_3), 104 ($PhN{=}CH^+$). Anal. Calcd for $C_{14}H_{12}F_3N$: C, 66.91; H, 4.82; N, 5.58. Found: C, 66.81; H, 5.01; N, 5.86.

***N*-Ethyl-*N*-(2,2,2-trifluoroethyl)-α-naphthylamine (4f):** yield 71%; ^{19}F NMR (CCl_4) δ 7.17 (t, $J_{H,F}$ = 9 Hz); ^1H NMR (CCl_4) δ 0.95 (t, 3 H, CH_3, *J* = 7 Hz), 3.23 (q, 2 H, CH_2, *J* = 7 Hz), 3.58 (q, 2 H, CH_2CF_3), 6.85–8.32 (m, 7H, naphthyl); MS *m/e* 253 (M^+), 138 (M^+ – Me), 184 (M^+ – CF_3). Anal. Calcd for $C_{14}H_{12}F_3N$: C, 66.91; H, 4.82; N, 5.58. Found: C, 66.81; H, 5.01; N, 5.89. Anal. Calcd for $C_{14}H_{12}F_3N$: C, 66.91; H, 4.82; N, 5.58. Found: C, 66.81; H, 5.01; N, 5.89.

***N*-(2,2,2-Trifluoroethyl)-1,2,3,4-tetrahydroquinoline (4g):** yield 92%; ^{19}F NMR ($CDCl_3$) δ 7.02 (t, $J_{H,F}$ = 9.1 Hz); ^1H NMR (CCl_4) δ 1.81 (tt, 2 H, CH_2, *J* = 6.4 and 5.9 Hz), 2.67 (t, 2 H, CH_2, *J* = 6.4 Hz), 3.27 (t, 2 H, CH_2, *J* = 5.9 Hz), 3.32 (q, 2 H, CH_2CF_3), 6.96–7.79 (m, 4 H, C_6H_4); MS *m/e* 215 (M^+), 146 (M^+ – CF_3). Anal. Calcd for $C_{11}H_{12}F_3N$: C, 61.37; H, 5.62; N, 6.51. Found: C, 61.51; H, 5.53; N, 6.63.

***N*-(2,2-Difluoroethyl)-*N*-methylaniline (5a):** yield 91%; ^{19}F NMR (CCl_4) δ −41.4 (dt, $J_{F,Hgem}$ = 54.4, $J_{F,Hvic}$ = 14.2 Hz); ^1H NMR (CCl_4) δ 2.93 (s, 3 H, CH_3), 3.50 (dt, 2 H, CHF_2CH_2, *J* = 4.2 Hz), 5.76 (tt, 1 H, CHF_2, *J* = 4.2 Hz), 6.39–7.27 (m, 5 H, Ph); MS *m/e* 171 (M^+). Anal. Calcd for $C_9H_{11}F_2N$: C, 63.12; H, 6.48; N, 8.19. Found: C, 63.35; H, 6.72; N, 8.09.

***N*-(2,2-Difluoroethyl)-*N*-ethylaniline (5b):** yield 86%; ^{19}F NMR (CCl_4) δ −42.3 (dt, $J_{F,Hgem}$ = 57.4, $J_{F,Hvic}$ = 15.4 Hz); ^1H NMR (CCl_4) δ 1.16 (t, 3 H, CH_3, *J* = 7 Hz), 3.37 (q, 2 H, CH_2, *J* = 7 Hz), 3.49 (dt, 2 H, CHF_2CH_2, *J* = 4.2 Hz), 5.73 (tt, 1 H, CHF_2, *J* = 4.2 Hz), 6.38–7.23 (m, 5H, Ph); MS *m/e* 185 (M^+), 170 (M^+ – Me), 134 (M^+ – CHF_2). Anal. Calcd for $C_{10}H_{13}F_2N$: C, 64.83; H, 7.08; N, 7.57. Found: C, 64.75; H, 7.11; N, 7.66.

***N*-(2,2-Difluoroethyl)-*N*-ethyl-*m*-toluidine (5c):** yield 85%; bp 89 °C (4.5 Torr); ^{19}F NMR (CCl_4) δ −43.3 (dt, $J_{F,Hgem}$ = 56.8, $J_{F,Hvic}$ = 14.4 Hz); ^1H NMR (CCl_4) δ 1.13 (t, 3 H, CH_3, *J* = 7 Hz), 2.29 (s, 3 H, $CH_3C_6H_4$), 3.32 (q, 2 H, CH_2, *J* = 7 Hz), 3.47 (dt, 2 H, CHF_2CH_2, *J* = 4.2 Hz), 5.73 (tt, 1 H, CHF_2, *J* = 4.2 Hz), 6.18–7.17 (m, 4 H, C_6H_4); MS *m/e* 199 (M^+), 138 (M^+ – CHF_2). Anal. Calcd for $C_{11}H_{15}F_2N$: C, 66.29; H, 7.59; N, 7.03. Found: C, 66.15; H, 7.73; N, 7.25.

***N*-(2,2-Difluoroethyl)-*N*-ethyl-*p*-toluidine (5d):** yield 86%; ^{19}F NMR (CCl_4) δ −45.0 (dt, $J_{F,Hgem}$ = 56.8, $J_{F,Hvic}$ = 14.2 Hz); ^1H NMR (CCl_4) δ 1.12 (t, 3 H, CH_3, *J* = 7 Hz), 2.20 (s, 3 H, $CH_3C_6H_4$), 3.33 (q, 2 H, CH_2, *J* = 7 Hz), 3.47 (dt, 2 H, CHF_2CH_2, *J* = 4.0 Hz), 5.72 (tt, 1 H, CHF_2, *J* = 4.0 Hz), 6.35–7.03 (m, 4 H, C_6H_4); MS *m/e* 199 (M^+), 184 (M^+ – Me, 148 (M^+ – CHF_2). Anal. Calcd for $C_{11}H_{15}F_2N$: C, 66.29; H, 7.59; N, 7.03. Found: C, 66.44; H, 7.50; N, 7.22.

***N*-(2,2-Difluoroethyl)-*N,N*-diphenylamine (5e):** yield 96%; ^{19}F NMR (CCl_4) δ −45.8 (dt, $J_{F,Hgem}$ = 54.8, $J_{F,Hvic}$ = 13.2 Hz); ^1H NMR (CCl_4) δ 3.90 (dt, 2 H, CH_2, *J* = 4.2 Hz), 5.77 (tt, 1 H, CHF_2, *J* = 4.2 Hz), 6.57–7.31 (m, 10 H, Ph); MS *m/e* 233 (M^+), 182 (M^+ – CHF_2). Anal. Calcd for $C_{14}H_{13}F_2N$: C, 72.07; H, 5.62; N, 6.01. Found: C, 71.96; H, 5.75; N, 6.00.

***N*-(2-Fluoroethyl)-*N*-methylaniline (6a):** yield 60%; ^1H NMR (CCl_4) δ 2.91 (s, 3 H, CH_3), 3.48 (dt, 2 H, CH_2FCH_2, *J* = 5.1 Hz, $J_{F,H}$ = 22.4 Hz), 4.38 (dt, 2 H, CH_2F, *J* = 5.1 Hz, $J_{F,H}$ = 46.1 Hz), 6.38–7.24 (m, 5 H, Ph); MS *m/e* 153 (M^+), 120 (M^+ – CH_2F). Anal. Calcd for $C_9H_{12}FN$; C, 70.54; H, 7.90; N, 9.15. Found: C, 70.29; H, 8.15; N, 9.03.

***N*-Ethyl-*N*-(2-fluoroethyl)aniline (6b):** yield 61% ; ^{19}F NMR (CCl_4) δ −116.5 (tt, $J_{F,Hgem}$ = 48.0, $J_{F,Hvic}$ = 22.5 Hz); ^1H NMR (CCl_4) δ 1.12 (t, 3 H, CH_3, *J* = 7 Hz), 3.33 (q, 2 H, CH_2, *J* = 7 Hz), 3.50 (dt, 2 H, CH_2FCH_2, *J* = 5.2 Hz, $J_{F,H}$ = 21.0 Hz), 4.38 (dt, 2 H, CH_2F, *J* = 5.2 Hz, $J_{F,H}$ = 42.1 Hz), 6.40–7.23 (m,

5 H, Ph); MS *m/e* 167 (M^+). Anal. Calcd for $C_{10}H_{14}FN$: C, 71.81; H, 8.44; N, 8.38. Found; C, 71.57; H, 8.48; N, 8.23.

***N*-Ethyl-*N*-(2-fluoroethyl)-*m*-toluidine (6c)**: yield 60%; ^1H NMR (CCl_4) δ 1.12 (t, 3 H, CH_3CH_2, J = 5.8 Hz), 2.23 (s, 3 H, $CH_3C_6H_4$), 3.33 (q, 2 H, CH_3CH_2, J = 5.8 Hz), 3.43 (dt, 2 H, CH_2FCH_2, J = 5.8 Hz, $J_{F,H}$ = 20.0 Hz), 4.38 (dt, 2 H, CH_2F, J = 4.5 Hz, $J_{F,H}$ = 38.3 Hz), 6.17–7.10 (m, 4 H, C_6H_4); MS *m/e* 181 (M^+). Anal. Calcd for $C_{11}H_{16}FN$: C, 72.89; H, 8.90; N, 7.73. Found: C, 72.60; H, 8.61; N, 7.52.

***N*-(2-Chloro-2,2-difluoroethyl)-*N*-ethylaniline (7a)**: yield 98%; ^1H NMR (CCl_4) δ 1.17 (t, 3 H, CH_3, J = 7.1 Hz), 3.43 (q, 2 H, CH_2, J = 7.1 Hz), 3.87 (t, 2 H, CF_2ClCH_2, $J_{H,F}$ = 12.2 Hz), 6.43–7.22 (m, 5 H, Ph); MS *m/e* 221 (M^+ + 2), 205 (M^+). Anal. Calcd for $C_{10}H_{12}F_2NCl$: C, 54.66; H, 5.51; N, 6.37. Found: C, 54.38; H, 5.78; N, 6.25.

***N*-(2-Chloro-2-fluoroethyl)-*N*-methylaniline (7b)**: yield 86%; ^{19}F NMR (CCl_4) δ −56.9 (ddd, $J_{F,Hgem}$ = 53.6, $J_{F,Hvic}$ = 18.0, $J_{F,Hvic}$ = 25.0 Hz); ^1H NMR (CCl_4) δ 3.03 (s, 3 H, CH_3), 3.52–3.83 (m, 2 H, $CHFClCH_2$), 6.14 (ddd, 1 H, CHFCl, J = 5.6, J = 5.6 Hz), 6.44–7.27 (m, 5 H, Ph); MS *m/e* 189 (M^+ + 2), 187 (M^+). Anal. Calcd for $C_9H_{11}FNCl$: C, 57.59; H, 5.91; N, 7.47. Found: C, 57.44; H, 6.20; N, 7.27.

***N*-(2-Chloro-2-fluoroethyl)-*N*-ethylaniline (7c)**: yield 70%; ^1H NMR (CCl_4) δ 1.11 (t, 3 H, CH_3, J = 7 Hz), 3.34 (q, 2 H, CH_2, J = 7 Hz), 3.50–3.82 (m, 2 H, $CHFClCH_2$), 6.14 (ddd, 1 H, CHFCl, $J_{F,Hgem}$ = 53.6, J = 5.4, J = 5.4 Hz), 6.45–7.30 (m, 5 H, Ph); MS *m/e* 203 (M^+ + 2), 201 (M^+). Anal. Calcd for $C_{10}H_{13}FNCl$: C, 59.53; H, 6.50; N, 6.95. Found: C, 59.44; H, 6.20; N, 7.20.

Anodic Methoxylation. Electrolysis of amines **4–7** (10 mmol) was carried out at a graphite plate anode (2.5 × 5 cm; Nihon Carbon) and a platinum cathode (3 × 4 cm) at room temperature in 0.34 M KOH/MeOH (35 mL) using an undivided cylindrical cell equipped with a magnetic stirrer. During the electrolysis, the electrolytic solution was cooled by using a water bath. After constant current (13.9 mA/cm^2) was passed until the starting amine was completely consumed [monitored by GC (column: Apeazon Grease L)], the electrolytic solution was concentrated and the remaining oil was chromatographed on silica gel (hexane–AcOEt, 6:1) to provide α-methoxy products **8–10**. The current efficiencies for **8**, **9**, and **10** were 1–45%, 12–52%, 30%, respectively.

***N*-(1-Methoxy-2,2,2-trifluoroethyl)-*N*-methylaniline (8a)**:[16c] ^{19}F NMR ($CDCl_3$) δ 2.0 (d, $J_{F,H}$ = 6 Hz); ^1H NMR ($CDCl_3$) δ 2.87 (s, 3 H, CH_3N), 3.30 (s, 3 H, CH_3O), 5.05 (q, 1 H, CF_3CH), 6.7–7.4 (m, 5 H, Ph); MS *m/e* 219 (M^+), 188 (M^+ − MeO), 150 (M^+ − CF_3), 135 (M^+ − CF_3 − Me), 106 ($PhNMe^+$). Anal. Calcd for $C_{10}H_{12}F_3NO$: C, 54.79; H, 5.52; N, 6.39. Found: C, 54.57; H, 5.82; N, 6.48.

***N*-Ethyl-*N*-(1-methoxy-2,2,2-trifluoroethyl)aniline (8b)**:[16c] ^{19}F NMR ($CDCl_3$) δ 1.8 (d, $J_{F,H}$ = 6 Hz); ^1H NMR ($CDCl_3$) δ 1.10 (t, 3 H, CH_3CH_2, J = 7 Hz), 3.33 (s, 3 H, CH_3O), 3.45 (q, 2 H, CH_3CH_2, J = 7 Hz), 4.94 (q, 1 H, CF_3CH), 6.7–7.3 (m, 5 H, Ph); MS *m/e* 233 (M^+), 202 (M^+ − MeO), 164 (M^+ − CF_3), 104 ($PhN{=}CH^+$). Anal. Calcd for $C_{11}H_{15}F_3NO$: C, 56.63; H, 6.05; N, 6.86. Found: C, 56.33; H, 6.35; N, 6.33.

***N*-Ethyl-*N*-(1-methoxy-2,2,2-trifluoroethyl)-*m*-toluidine (8c)**: ^{19}F NMR (CCl_4) δ 0.58 (d, $J_{F,H}$ = 6 Hz); ^1H NMR (CCl_4) δ 1.09 (t, 3H, CH_3, J = 7.6 Hz), 2.24 (s, 3 H, $CH_3C_6H_4$), 3.28 (s, 3 H, OCH_3), 3.41 (q, 2 H, CH_2, J = 7.6 Hz), 4.80 (q, 1 H, CF_3CH), 6.60–7.07 (m, 4 H, $C6H_4$); MS *m/e* 247 (M^+), 216 (M^+ − OCH_3), 178 (M^+ − CF_3); calcd for $C_{12}H_{16}F_3NO$ *m/e* 247.1183, found 247.1201.

***N*-Ethyl-*N*-(1-methoxy-2,2,2-trifluoroethyl)-*p*-toluidine (8d)**: ^{19}F NMR (CCl_4) δ 0.52 (d, $J_{F,H}$ = 5.8 Hz); ^1H NMR (CCl_4) δ 1.08 (t, 3 H, CH_3, J = 7.4 Hz), 2.27 (s, 3 H, $CH_3C_6H_4$), 3.26 (s, 3 H, OCH_3), 3.42 (q, 2 H, CH_2, J = 7.6 Hz), 4.87 (q, 1 H, CF_3CH), 6.28–7.22 (m, 4 H, C_6H_4); MS *m/e* 247 (M^+), 216 (M^+ − OCH_3), 178 (M^+ − CF_3); calcd for $C_{12}H_{16}F_3NO$ *m/e* 247.1183, found 247.1201.

***N*-(1-Methoxy-2,2,2-trifluoroethyl)diphenylamine (8e)**:[16c] ^{19}F NMR ($CDCl_3$) δ 4.08 (d, $J_{F,H}$ = 6 Hz); ^1H NMR ($CDCl_3$) δ 3.53 (s, 3 H, CH_3O), 5.30 (q, 1 H, CF_3CH), 6.8–7.4 (m, 10 H, Ph); MS *m/e* 281 (M^+), 250 (M^+ − MeO), 212 (M^+ − CF_3), 168 (Ph_2N^+). Anal. Calcd for $C_{15}H_{14}F_3NO$: C, 64.03; H, 5.02; N, 4.98. Found: C, 63.74; H, 5.26; N, 4.82.

***N*-Ethyl-*N*-(1-methoxy-2,2,2-trifluoroethyl)-α-naphthylamine (8f)**: ^{19}F NMR (CCl_4) δ 1.03 (d, $J_{F,H}$ = 5.6 Hz); ^1H NMR (CCl_4) δ 0.97 (t, 3 H, CH_3, J = 6.8 Hz), 3.40 (q, 2 H, CH_2, J = 6.8 Hz), 3.48 (s, 3 H, OCH_3), 4.38 (q, 1 H, CF_3CH), 7.03–8.40 (m, 7 H, naphthyl); MS *m/e* 183 (M^+), 114 (M^+ − CF_3). Anal. Calcd for $C_{15}H_{16}F_3NO$: C, 63.60; H, 5.69; N, 4.94. Found: C, 63.88; H, 5.39; N, 4.65.

***N*-(1-Methoxy-2,2,2-trifluoroethyl)-1,2,3,4-tetrahydroquinoline (8g)**: ^1H NMR (CCl_4) δ 1.77 (tt, 2 H, NCH_2CH_2, J = 6.4 Hz), 2.78 (2 H, $NCH_2CH_2CH_2$, J = 6.4 Hz), 3.30 (t, 2 H, NCH_2, J = 6.0 Hz), 3.34 (s, 3 H, OCH_3), 5.05 (q, 1 H, CF_3CH, $J_{F,H}$ = 5.2 Hz), 6.34–7.04 (m, 4 H, C_6H_4); MS *m/e* 245 (M^+), 176 (M^+ − CF_3). Anal. Calcd for $C_{12}H_{14}F_3NO$: C, 58.77; H, 5.57; N, 5.71. Found: C, 58.99; H, 5.65; N, 5.93.

***N*-(2,2,2-Trifluoroethyl)-1,4-dihydroquinoline (8h)**: ^1H NMR (CCl_4) δ 3.45 (bd, 2 H, CH_2, J = 3.4 Hz), 3.80 (q, 2 H, CF_3CH_2, $J_{F,H}$ = 8.6 Hz), 4.50 (dt, 1 H, NCH=C*H*, J = 3.4 and 8.0 Hz), 5.77 (d, 1 H, NCH, J = 8.0 Hz), 6.32–7.05 (m, 4 H, C_6H_4); MS *m/e* 213 (M^+, trace), 144 (M^+ − CF_3). Anal. Calcd for $C_{11}H_{10}F_3NO$: C, 61.95; H, 4.73; N, 6.57. Found: C, 62.13; H, 4.88; N, 6.80.

***N*-(2,2-Difluoro-1-methoxyethyl)-*N*-methylaniline (9a)**: ^{19}F NMR (CCl_4) δ −49.0 (dd, $J_{F,Hgem}$ = 57.4, $J_{F,Hvic}$ = 7.6 Hz); ^1H NMR (CCl_4) δ 2.92 (s, 3 H, NCH_3), 3.30 (s, 3 H, OCH_3), 4.73 (m, 1 H, CHF_2CH), 5.67 (dt, 1 H, CHF_2), 6.50–7.30 (m, 5 H, Ph); MS *m/e* 201 (M^+), 170 (M^+ − OCH_3), 150 (M^+ − CHF_2). Anal. Calcd for $C_{10}H_{13}F_2NO$: C, 59.69; H, 6.51; N, 6.96. Found: C, 59.97; H, 6.80; N, 6.71.

***N*-Ethyl-*N*-(2,2-difluoro-1-methoxyethyl)aniline (9b)**: ^1H NMR (CCl_4) δ 1.17 (t, 3 H, CH_3, J = 6.8 Hz), 3.27 (s, 3H, OCH_3), 3.30 (q, 2 H, CH_2, J = 6.8 Hz), 4.60 (dt, 1 H, CHF_2CH, $J_{F,Hvic}$ = 8.1 Hz, J = 5.7 Hz), 5.63 (dt, 1 H, CHF_2, $J_{F,Hgem}$ = 54.6 Hz, J = 5.7 Hz), 6.63–7.27 (m, 5 H, Ph); MS *m/e* 215 (M^+), 184 (M^+ − OCH_3), 164 (M^+ − CHF_2). Anal. Calcd for $C_{11}H_{15}F_2NO$: C, 61.36; H, 7.03; N, 6.51. Found: C, 61.58; H, 7.21; N, 6.44.

***N*-Ethyl-*N*-(2,2-difluoro-1-methoxyethyl)-*m*-toluidine (9c)**: ^1H NMR (CCl_4) δ 1.13 (t, 3 H, CH_3, J = 7.0 Hz), 2.23 (s, 3 H, $CH_3C_6H_4$), 3.27 (s, 3 H, OCH_3), 3.30 (q, 2 H, CH_2, J = 6.8 Hz), 4.53 (dt, 1 H, CHF_2CH, $J_{F,Hvic}$ = 7.4 Hz, J = 5.0 Hz), 5.63 (dt, 1 H, CHF_2, $J_{F,Hgem}$ = 55.2 Hz, J = 5.0 Hz), 6.64–7.08 (m, 3 H, C_6H_4); MS *m/e* 229 (M^+), 198 (M^+ − OCH_3), 178 (M^+ − CHF_2). Anal. Calcd for $C_{12}H_{17}F_2NO$: C, 62.87; H, 7.47; N, 6.11. Found: C, 63.02; H, 7.35; N, 6.29.

***N*-Ethyl-*N*-(2,2-difluoro-1-methoxyethyl)-*p*-toluidine (9d)**: ^1H NMR (CCl_4) δ 1.15 (t, 3 H, CH_3, J = 7.0 Hz), 2.21 (s, 3 H, $CH_3C_6H_4$), 3.30 (s, 3 H, OCH_3), 3.32 (q, 2 H, CH_2, J = 7.0 Hz), 4.51 (dt, 1 H, CHF_2CH, $J_{F,Hvic}$ = 7.4 Hz, J = 4.8 Hz), 5.63 (dt, 1 H, CHF_2, $J_{F,Hgem}$ = 55.2 Hz, J = 4.8 Hz), 6.37–7.17 (m, 4 H, C_6H_4); MS *m/e* 229 (M^+), 198 (M^+ − OCH_3), 178 (M^+ − CHF_2). Anal. Calcd for $C_{12}H_{17}F_2NO$: C, 62.87; H, 7.47; N, 6.11. Found: C, 62.58; H, 7.61; N, 6.00.

***N*-(2,2-Difluoro-1-methoxyethyl)diphenylamine (9e)**: ^{19}F NMR (CCl_4) δ −50.2 (ddd, $J_{F,F}$ = 290 Hz, $J_{F,Hgem}$ = 56.6 Hz, $J_{F,Hvic}$ = 7.6 Hz), −48.7 (ddd, $J_{F,F}$ = 290 Hz, $J_{F,Hgem}$ = 61.8 Hz, $J_{F,Hvic}$ = 4.2 Hz); ^1H NMR (CCl_4) δ 3.40 (s, 3 H, OCH_3), 4.86 (m, 1 H, CHF_2CH), 5.63 (dt, 1 H, CHF_2, J = 5.8 Hz), 6.62–7.32 (m, 10 H, Ph); MS *m/e* 263 (M^+), 232 (M^+ − OCH_3), 212 (M^+ − CHF_2); calcd for $C_{15}H_{15}F_2NO$ 263.1121, found 263.1145.

***N*-(2-Fluoroethyl)-*N*-(methoxymethyl)aniline (10a′)**: ^1H NMR (CCl_4) δ 3.20 (s, 3 H, OCH_3), 3.62 (dt, 2 H, CH_2FCH_2, $J_{F,H}$ = 20.8 Hz, J = 5.0 Hz), 4.43 (dt, 2 H, CH_2F, $J_{F,Hgem}$ = 46.4 Hz), 4.57 (s, 2 H, CH_2OCH_3), 6.47–7.25 (m, 5 H, Ph); MS *m/e* 183 (M^+), 152 (M^+ − OCH_3), 150 (M^+ − CH_2F). Anal. Calcd for $C_{10}H_{14}FNO$: C, 65.55; H, 7.70; N, 7.64. Found: C, 65.30; H, 7.95; N, 7.35.

***N*-Ethyl-*N*-(2-fluoro-1-methoxyethyl)aniline (10b)**: ^1H NMR (CCl_4) δ 1.13 (t, 3 H, CH_3, J = 7.0 Hz), 3.22 (s, 3 H, OCH_3), 3.34 (q, 2 H, CH_2, J = 7.0 Hz), 3.80 (m, 1 H, CH_aF), 4.02 (m, 1 H, CH_bF), 4.75 (m, 1 H, CH), 6.37–7.20 (m, 5 H, Ph); MS *m/e* 197 (M^+), 164 (M^+ − CH_2F). Anal. Calcd for $C_{11}H_{16}FNO$: C, 66.95; H, 8.18; N, 7.10. Found: C, 66.71; H, 8.33; N, 7.01.

Preparation of Trifluoromethyl and Difluoromethyl α-Amino Nitriles 12 and 13. To a stirred solution of α-methoxy amine **8** or **9** (1.5 mmol) and cyanotrimethylsilane (2.4 mmol) in 3 mL of CH_2Cl_2 was added dropwise a solution of $TiCl_4$ or BF_3·OEt_2 (2.4 mmol). After 0.5 h of stirring, the temperature of

the solution was raised to −20 °C and was stirred for 2 h, and then 1.5 mL of pyridine was added in order to quench the reaction. To the reaction mixture was added saturated aqueous $NaHCO_3$, and the resulting solution was extracted repeatedly with CH_2Cl_2 and washed with aqueous HCl and brine. The extracts were dried (Na_2SO_4) and evaporated. The residue was chromatographed on silica gel (hexane–AcOEt, 6:1) to provide the pure α-amino nitrile **12** or **13**.

***N*-(1-Cyano-2,2,2-trifluoroethyl)-*N*-ethylaniline (12b)**: ^{19}F NMR (CCl_4) δ 4.63 (d, $J_{F,H}$ = 7.20 Hz); ^1H NMR (CCl_4) δ 1.13 (t, 3 H, CH_3, J = 7.04 Hz), 3.43 (q, 2 H, CH_2, J = 7.04 Hz), 4.75 (q, 1 H, CH), 9.60 (m, 5 H, Ph); MS *m/e* 228 (M^+), 203 ($M^+ - CH_3$), 159 ($M^+ - CF_3$). Anal. Calcd for $C_{11}H_{11}N_2F_3$: C, 57.89; H, 4.86; N, 12.27. Found: C, 58.05; H, 4.81; N, 11.97.

***N*-(1-Cyano-2,2,2-trifluoroethyl)-*N*-ethyl-*p*-toluidine (12d)**: ^{19}F NMR (CCl_4) δ 4.73 (d, $J_{F,H}$ = 7.36 Hz); ^1H NMR (CCl_4) δ 1.10 (t, 3 H, CH_3CH_2, J = 7.60 Hz), 2.25 (s, 3 H, $CH_3C_6H_4$), 3.37 (q, 2 H, CH_2, J = 7.60 Hz), 4.64 (q, 1 H, CH), 6.92 (m, 4 H, C_6H_4); MS *m/e* 242 (M^+), 227 ($M^+ - CH_3$), 173 ($M^+ - CF_3$), 145 ($M^+ - CH(CN)CF_3$); calcd for $C_{12}H_{13}F_3N_2$ 242.1030, found 242.1068.

***N*-(1-Cyano-2,2,2-trifluoroethyl)diphenylamine (12e)**: ^{19}F NMR (CCl_4) δ 7.30 (d, $J_{F,H}$ = 8.30 Hz); ^1H NMR (CCl_4) δ 5.40 (t, 1 H, CH), 7.12 (m, 10 H, Ph); MS *m/e* 276 (M^+), 207 ($M^+ - CF_3$). Anal. Calcd for $C_{15}H_{11}F_3N_2$: C, 65.22; H, 4.01; N, 10.14. Found: C, 65.01; H, 3.75; N, 10.36.

***N*-(1-Cyano-2,2-difluoroethyl)-*N*-ethylaniline (13b)**: ^{19}F NMR (CCl_4) δ −40.6 (ddd, $J_{F,F}$ = 294 Hz, $J_{F,Hgem}$ = 56.0 Hz, $J_{F,Hvic}$ = 11.4 Hz), −46.5 (ddd, $J_{F,F}$ = 294 Hz, $J_{F,Hgem}$ = 56.0 Hz, $J_{F,Hvic}$ = 13.2 Hz); ^1H NMR (CCl_4) δ 1.09 (t, 3 H, CH_3, J = 7.30 Hz), 3.97 (q, 2 H, CH_2, J = 7.30 Hz), 4.47 (ddd, 1 H, CHF_2CH, J = 3.92 Hz), 5.75 (dt, 1 H, CHF_2), 6.52–7.33 (m, 5 H, Ph); MS *m/e* 210 (M^+), 159 ($M^+ - CHF_2$); calcd for $C_{11}H_{12}F_2N_2$ 210.0967, found 210.0964.

***N*-(1-Cyano-2,2-difluoroethyl)-*N*-ethy-*m*-toluidine (13c)**: ^{19}F NMR (CCl_4) δ −40.5 (ddd, $J_{F,F}$ = 295 Hz, $J_{F,Hgem}$ = 56.6 Hz, $J_{F,Hvic}$ = 10.6 Hz), −46.6 (ddd, $J_{F,F}$ = 295 Hz, $J_{F,Hgem}$ = 56.6 Hz, $J_{F,Hvic}$ = 13.4 Hz); ^1H NMR (CCl_4) δ 1.12 (t, 3 H, CH_3CH_2, J = 7.12 Hz), 2.29 (s, 3 H, $CH_3C_6H_4$), 3.26 (q, 2 H, CH_2, J = 7.12 Hz), 4.38 (ddd, 1 H, CHF_2CH, J = 4.05 Hz), 5.75 (dt, 1 H, CHF_2, J = 4.05 Hz), 6.52–7.36 (m, 4 H, C_6H_4); MS *m/e* 224 (M^+), 173 ($M^+ - CHF_2$). Anal. Calcd for $C_{12}H_{14}F_2N_2$: C, 64.27; H, 6.29; N, 12.49. Found: C, 64.56; H, 6.01; N, 12.21.

Preparation of 2-(Fluoromethyl)-1,2,3,4-tetrahydroquinolines 14 and 2-(Fluoromethyl)-1,2-dihydroquinolines 15. To a stirred solution of 1.5 mmol of **8** or **9** and 0.172 g (1.65 mmol) of styrenes in 2 mL of CH_2Cl_2 was added dropwise 1.5 mmol of $TiCl_4$ or $BF_3{\cdot}Et_2O$ at −78 °C under a nitrogen atmosphere. After 1 h of stirring, the solution was mixed with aqueous $NaHCO_3$ and extracted with CH_2Cl_2. The extracts were dried (Na_2SO_4) and evaporated. The residue was chromatographed on silica gel (hexane–AcOEt, 10:1) to provide pure **14** or **15**.

1-Ethyl-4-phenyl-2-(trifluoromethyl)-1,2,3,4-tetrahydroquinoline (14b): ^{19}F NMR ($CDCl_3$) trans isomer δ 5.08 (d, $J_{F,H}$ = 6.40 Hz); cis isomer δ 6.57 (d, $J_{F,H}$ = 7.84 Hz); ^1H NMR ($CDCl_3$) trans isomer δ 1.18 (t, 3 H, CH_3, J = 7.00 Hz), 2.22 (ddd, 1 H, $PhCHCH_aH_b$, J = 12.8, 12.8, and 9.80 Hz), 2.54 (ddd, 1 H, $PhCHCH_aH_b$, J = 12.8, 7.80, and 3.80 Hz), 3.41 (dq, 1 H, $CH_3CH_cH_d$, J = 7.20 and 7.20 Hz), 3.69 (dq, 1 H, $CH_3CH_cH_d$, J = 7.20 and 7.20 Hz), 3.78 (dd, 1 H, PhCH, J = 12.8 and 4.00 Hz), 3.99 (ddq, 1 H, CF_3CH, J = 9.80 and 7.80 Hz, $J_{F,H}$ = 6.40 Hz), 6.43–7.46 (m, 9 H, Ph and C_6H_4); MS *m/e* 305 (M^+), 290 ($M^+ - CH_3$), 276 ($M^+ - C_2H_5$), 236 ($M^+ - CF_3$). Anal. Calcd for $C_{18}H_{18}F_3N$: C, 70.81; H, 5.94; N, 4.59. Found: C, 70.53; H, 5.80; N, 4.85.

1-Phenyl-4-(*p*-tolyl)-2-(trifluoromethyl)-1,2,3,4-tetrahydroquinoline (14d): mp 129–131 °C; ^{19}F NMR ($CDCl_3$) trans isomer δ 4.75 (d, $J_{F,H}$ = 6.60 Hz); cis isomer δ 6.63 (d, $J_{F,H}$ = 7.84 Hz); ^1H NMR ($CDCl_3$) trans isomer δ 2.23–2.44 (m, 1 H, *p*-TolCHCH_aH_b), 2.38 (s, 3 H, $CH_3C_6H_4$), 2.68 (ddd, 1 H, *p*-TolCHCH_aH_b, J = 12.8, 8.80, and 3.60 Hz), 3.82 (dd, 1 H, *p*-TolCH, J = 13.2 and 3.6 Hz), 4.42–4.64 (m, 1 H, CF_3CH), 6.62–7.45 (m, 13 H, Ph and C_6H_4); MS *m/e* 367 (M^+), 298 ($M^+ - CF_3$), 206 ($M^+ - CF_3$ – *p*-Tol). Anal. Calcd for $C_{21}H_2OF_3N$: C, 75.19; H, 5.49; N, 3.81. Found: C, 74.98; H, 5.70; N, 3.99.

1,4-Diphenyl-2-(trifluoromethyl)-1,2,3,4-tetrahydroquinoline (14e): mp 118–120 °C; ^{19}F NMR ($CDCl_3$) trans isomer δ 4.92 (d, $J_{F,H}$ = 6.80 Hz); cis isomer δ 6.67 (d, $J_{F,H}$ = 8.20 Hz); ^1H NMR ($CDCl_3$) trans isomer δ 2.30 (ddd, 1 H, $PhCHCH_aH_b$, J = 13.2, 13.2, and 8.80 Hz), 2.62 (ddd, 1 H, $PhCHCH_aH_b$, J = 13.2, 8.60, and 4.00 Hz), 3.78 (dd, 1 H, PhCH, J = 13.2 and 4.00 Hz), 4.47 (ddq, 1 H, CF_3CH, J = 8.80 and 8.60 Hz, $J_{F,H}$ = 6.60 Hz), 6.52–7.44 (m, 14 H, Ph and C_6H_4); MS *m/e* 353 (M^+), 284 ($M^+ - CF_3$). Anal. Calcd for $C_{22}H_{18}F_3N$: C, 74.77; H, 5.13; N, 3.96. Found: C, 74.98; H, 5.34; N, 3.75.

1-Phenyl-2-(difluoromethyl)-4-(*p*-tolyl)-1,2,3,4-tetrahydroquinoline (15d): ^{19}F NMR ($CDCl_3$) trans isomer δ −42.9 (ddd, $J_{F,F}$ = 260 Hz, $J_{F,Hgem}$ = 51.6 Hz, $J_{F,Hvic}$ = 7.60 Hz); cis isomer δ −50.7 (ddd, $J_{F,F}$ = 260 Hz, $J_{F,Hgem}$ = 58.4 Hz, $J_{F,Hvic}$ = 15.7 Hz); ^1H NMR ($CDCl_3$) trans isomer δ 2.32–2.58 (m, 2 H, *p*-TolCHCH_2), 2.34 (s, 3 H, $CH_3C_6H_4$), 4.01–4.22 (m, 2 H, *p*-TolCH, CHF_2CH), 5.57 (dt, 1 H, CHF_2, J = 4.0 Hz), 6.62–7.42 (m, 13 H, Ph and C_6H_4); MS *m/e* 349 (M^+). Anal. Calcd for $C_{23}H_{21}F_2N$: C, 79.06; H, 6.06; N, 4.01. Found: C, 78.88; H, 6.25; N, 4.23.

1,4-Diphenyl-2-(difluoromethyl)-1,2,3,4-tetrahydroquinoline (15e): ^{19}F NMR ($CDCl_3$) trans isomer δ −43.2 (ddd, $J_{F,F}$ = 258 Hz, $J_{F,Hgem}$ = 51.4 Hz, $J_{F,Hvic}$ = 7.60 Hz); cis isomer δ −50.8 (ddd, $J_{F,F}$ = 258 Hz, $J_{F,Hgem}$ = 51.4 Hz, $J_{F,Hvic}$ = 13.4 Hz); ^1H NMR ($CDCl_3$) trans isomer δ 2.33–2.60 (m, 2 H, $PhCHCH_2$), 4.02–4.23 (m, 2 H, PhCH and CHF_2CH), 5.59 (dt, 1 H, CHF_2, J = 3.60 Hz), 6.60–7.42 (m, 14 H, Ph and C_6H_4); MS *m/e* 335 (M^+). Anal. Calcd for $C_{22}H_{19}F_2N$: C, 78.79; H, 5.71; N, 4.17. Found: C, 78.50; H, 5.99; N, 3.98.

1,4-Diphenyl-2-(trifluoromethyl)-1,2-dihydroquinoline (16e): ^{19}F NMR ($CDCl_3$) δ −2.03 (d, $J_{F,H}$ = 7.2 Hz); ^1H NMR ($CDCl_3$) δ 4.87 (dq, 1 H, CF_3CH, J = 7.0 Hz), 5.67 (d, 1 H, CF_3CHCH), 6.78–7.46 (m, 14 H, Ph and C_6H_4); MS *m/e* 351 (M^+), 282 ($M^+ - CF_3$); calcd for $C_{22}H_{16}F_3N$ 351.1234, found 351.1255.

2-(Difluoromethyl)-1,4-diphenyl-1,2-dihydroquinoline (17e): ^{19}F NMR ($CDCl_3$) δ −49.7 (ddd, $J_{F,F}$ = 278 Hz, $J_{F,Hgem}$ = 57.6 Hz, $J_{F,Hvic}$ = 8.2 Hz), −41.7 (ddd, $J_{F,F}$ = 278 Hz, $J_{F,Hgem}$ = 55.0 Hz, $J_{F,Hvic}$ = 9.4 Hz); ^1H NMR ($CDCl_3$) δ 4.66 (dddd, 1 H, CHF_2CH, J = 6.6 and 6.2 Hz), 5.67 (ddd, 1 H, CHF_2, J = 6.2 Hz), 5.73 (dd, 1 H, CHF_2CHCH, J = 6.6 and 2.0 Hz), 6.83 and 7.05–7.46 (m, 14 H, Ar H); MS *m/e* 333 (M^+), 282 ($M^+ - CHF_2$). Anal. Calcd for $C_{22}H_{17}F_2N$: C, 79.26; H, 5.14; N, 4.20. Found: C, 79.00; H, 5.34; N, 4.48.

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Supplementary Material Available: ^1H NMR spectra of new compounds (6 pages). This material is contained in libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.