

REACTIONS OF SECONDARY AMINES WITH METHYL TRIFLUOROACRYLATE

O. PALETA, J. OKROUHLÍK and V. KUBELKA

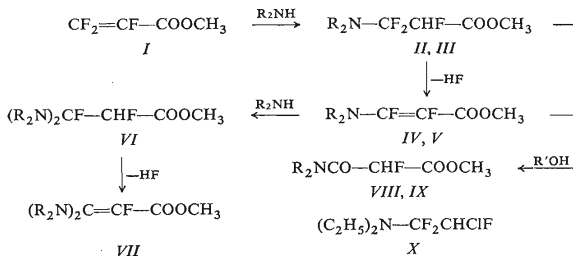
*Department of Organic Chemistry, and Mass Spectrometry Department,
Institute of Chemical Technology, 166 28 Prague 6*

Received September 18th, 1973

The reaction of diethylamine and diisopropylamine with methyl trifluoroacrylate was studied, giving a series of products depending on the reaction conditions. On reaction of primary addition products, methyl 3-dialkylamino-2,3,3-trifluoropropionates *II* and *III*, with alcohols N,N-dialkyl-fluoromalonomates (*VIII*, *IX*) were formed.

The reaction of fluorinated olefins with secondary amines is known from several papers¹⁻³. Fluorinated ethylenes, as for example tetrafluoroethylene or trifluorochlorethylene, afford under mild conditions products⁴⁻⁶ that were found useful in preparative chemistry⁷⁻⁹. In connection with this we were interested in the behaviour of methyl trifluoroacrylate during its reaction with some secondary amines. From our preceding experience¹⁰ it followed that the olefinic bond in methyl trifluoroacrylate has similar properties as in highly fluorinated olefins.

The reaction of diethylamine with methyl trifluoroacrylate (*I*) at room temperature is very vigorous. Among the reaction products we identified as the main component methyl 3-bis(diethylamino)-2-fluoroacrylate (*VI*). In order to obtain the primary addition product, methyl 3-diethylamino-2,3,3-trifluoropropionate (*II*), we carried out the reaction at -30 to -50°C in ether. In contrast to a similar adduct of the



In formulae *II*, *IV*, *VI*, *VII*, *VIII*; $\text{R} = \text{C}_2\text{H}_5$; *III*, *V*, *IX*; $\text{R} = (\text{CH}_3)_2\text{CH}$, $\text{R}' = \text{CH}_3$, $n\text{-C}_4\text{H}_9$

reaction of trifluorochloroethylene with diethylamine⁷⁻⁹, which can be distilled, the adduct *II* was found to be a very instable compound. During the isolation of adduct *II* the temperature of the reaction mixture did not exceed 0°C, but in spite of this 15% of compound *II* was converted according to NMR analysis to a product of dehydrofluorination, methyl 3-diethylamino-2,3-difluoroacrylate (*IV*). Due to low stability of adduct *II* we were unable to prove substance *II* in the same mixture by mass spectrum on an apparatus with a heated chromatographic inlet. The reaction, carried out at -20 to 0°C and using an excess of diethylamine, gave after distillation a mixture of 3,3-bis(diethylamino)-2,3-difluoropionate *VI* and fluoroacrylate *VII*.

Similarly as diethylamine diisopropylamine also reacted with acrylate *I*. From the reaction carried out at -30 to 0°C we isolated the product of secondary dehydrofluorination reaction as the main component, *i.e.* methyl 3-diisopropylamino-2,3-difluoroacrylate (*V*), while the primary adduct *III* could not be isolated.

Literature^{5,6} describes addition reactions of some less basic secondary amines and related substances, such as amides and lactams, with fluorinated ethylenes. The additions took place in the presence of alkali metals only. We were interested in the reactivity of methyl trifluoroacrylate

TABLE I

PMR Spectra of Compounds *II*–*IX* (deuteriochloroform); chemical shift (number of protons); s singlet, d doublet, t triplet, q quadruplet, m multiplet; coupling constant *J* c/s

Compound	Character of peaks
<i>II</i> ^a	dt 5.12 (1), ² <i>J</i> _{HF} = 46.2, —CHF—CF ₂ —; s 3.86 (3), COOCH ₃ ; q 2.98 (4), ³ <i>J</i> _{HH} = 7.1, —N(CH ₂ —) ₂ ; t 1.10 (6), ³ <i>J</i> _{HH} = 7.6, (CH ₃) ₂
<i>IV</i> ^a	s 3.79 (3), COOCH ₃ ; q 3.31 (4), ³ <i>J</i> _{HH} = 7.2, N(CH ₂ —) ₂ ; t 1.22 (6), ³ <i>J</i> _{HF} = 6.8, (CH ₃) ₂
<i>V</i> ^a	s 3.79 (3), COOCH ₃ ; m 3.32–3.92 (2), —N(CH=) ₂ ; d 1.26 (12), ³ <i>J</i> _{HH} = 6.8, C(CH ₃) ₂
<i>VII</i> ^b	s 3.75 (3), —COOCH ₃ ; q 3.11 (8), (—N(CH ₂ —) ₂) ₂ ; t 1.08 (12), C(CH ₃) ₂
<i>VIII</i> ^b	d 5.53 (1), ² <i>J</i> _{HF} = 48.8, —CHF—; s 3.85 (3), COOCH ₃ ; q 3.41 (8), ³ <i>J</i> _{HH} = 7.1, —N(CH ₂ —) ₂ ; t 1.22 ^c (3), ³ <i>J</i> _{HH} = 7.1, CH ₃ ; t 1.15 ^c (3), ³ <i>J</i> _{HH} = 7.2, CH ₃
<i>IX</i> ^a	d 5.44 (1), ² <i>J</i> _{HF} = 48.8, —CHF—; s 4.86 (3), COOCH ₃ ; m 4.06 (1), —CH=; m 3.48 (1), —CH=; d 1.42 (6), ³ <i>J</i> _{HH} = 7.4, C(CH ₃) ₂ ; qt 1.22 (6), ³ <i>J</i> _{HH} = 5.7, C(CH ₃) ₂

^aSpectrum at 100 MHz; ^bspectrum at 60 MHz; ^c the signals merge into a single one at 60°C.

with these less reactive secondary bases. At room temperature pyrrole did not give any addition product. Similarly *N*-ethylformamide and *N*-ethylacetamide did not afford any addition product either when the reaction was carried out at 70–80°C in dimethoxyethane under catalysis with sodium.

The adduct obtained on addition of diethylamine to trifluorochloroethylene *X* has the ability of substituting fluorine for hydroxyl group (see⁷⁻⁹). The reaction takes place most easily with primary alcohols. The primary adduct *II* has a similar structure as reagent *X*. Therefore we tried to determine whether it also has similar fluorinating properties. The reaction of adduct *II* was carried out with 1-butanol in the cold and also under heating, but in no case were we able to obtain 1-fluorobutane. Dibutyl ether and methyl *N,N*-diethylfluoromalonamate (*VIII*) were identified as reaction products. This ester amide was also isolated from the reaction of acrylate *I* with

TABLE II

Absorption Maxima in the Infrared Spectra of Compounds *I, II, IV, V, VII–IX* (cm⁻¹; carbon disulfide, tetrachloromethane)

Compound	ν (C=O)	ν (C=C)	ν (=C—N)	Other bands
<i>I</i>	1 747 s 1 768 s	1 728 m	—	1 084 vs, 1 188 m, 1 210 s, 1 327 s, 1 357 s, 1 368 ms, 1 441 m, 2 958 mw
<i>II</i>	1 745 s	—	—	975 m, 1 026 m, 1 097 s, 1 128 s, 1 233 s, 1 261 s, 1 300 s, 1 382 m, 1 438 s, 2 878 m, 2 937 m, 2 956 m, 2 980 m
<i>IV</i>	1 764 m	1 723 s	1 662 vs	1 079 s, 1 142 s, 1 154 s, 1 190 s, 1 319 s, 1 382 m, 1 438 m, 2 938 m, 2 950 m, 2977 ms
<i>V</i>	1 764 s	1 724 m	1 661 vs	1 075 m, 1 093 m, 1 133 ms, 1 153 s, 1 200 s, 1 271 m, 1 297 s, 1 318 s, 1 370 m, 1 437 s, 2 935 m, 2 952 m, 2 973 m
<i>VII</i>	1 764 w	1 687 s	1 561 s	1 070 s, 1 112 s, 1 186 s, 1 197 ms, 1 214 s, 1 271 s, 1 294 s, 1 309 s, 1 340 m, 1 376 ms, 1 436 s, 1 481 m, 2 870 m, 2 930 m, 2 968 s
<i>VIII</i>	1 765 s 1 781 s(sh)	—	—	1 030 m, 1 099 s, 1 211 s, 1 263 m, 1 289 m, 1 383 m, 1 437 ms, 1 448 m, 1 462 m, 1 664 vs ν (CO—N), 2 935 m, 2 952 m, 2 973 m, 3 004 w(sh)
<i>IX</i>	1 764 s 1 781 ms(sh)	—	—	1 040 m, 1 095 m, 1 137 m, 1 158 m, 1 208 s, 1 264 m, 1 330 m, 1 342 m, 1 370 ms, 1 379 m, 1 437 s, 1 444 s, 1 473 m, 1 662 vs ν (CO—N), 2 934 m, 2 952 m(sh), 2 970 ms, 3 005 mw

diethylamine at room temperature and after the decomposition of the reaction mixture with methanol. Ester *IX* was also prepared in an analogous manner.

EXPERIMENTAL

The temperature data are not corrected. Gas chromatography was carried out on a Chrom 3 apparatus (Laboratorní přístroje, Prague; FID, nitrogen as carrier gas, column diameter 0.6 cm; support of the stationary phase Chromaton N-AW-DMCS, Lachema, Brno). The infrared spectra were measured on a Perkin-Elmer 325 (Bodenseewerk) instrument, the ultraviolet spectra on an Optica Milano CF 4 NI apparatus, the PMR spectra on a BSS 477 (Tesla Brno, 60 MHz) and a Varian XL-100-15 (Palo Alto) apparatus. The mass spectra were measured with a Gas Chromatograph-Mass Spectrometer LKB-9000 (Stockholm; one focus, 70 eV electron energy; gas chromatography inlet: poly(ethylene glycol adipate), support Chromaton N-AW, glass column 250 cm, column diameter 0.23, helium gas 10 ml/min).

Chemicals used: methyl trifluoroacrylate (*I*) was prepared according to our own method^{11,12}. Diethylamine and di-isopropylamine were dried with solid sodium hydroxide and then distilled under argon.

Reaction of Methyl Trifluoroacrylate with Diethylamine

A. To a solution of methyl trifluoroacrylate (3.12 g; 22.2 mol) in diethyl ether (5 ml) diethylamine (0.91 g; 12.3 mmol) was added at -50 to -60°C under stirring with nitrogen over 30 minutes. The temperature of the reaction mixture rose within 1.5 hours to 0°C and the unreacted material was distilled off in a vacuum. The residue (2.25 g) containing products *II* and *IV* (55 and 45% rel.) was used for spectral analysis. For the spectra of compounds *II* and *IV* see

TABLE III
Mass Spectra of Compounds *IV*, *VI*–*VIII* (mass m/e , relative intensity)

Compound	Ionic species
<i>IV</i>	193 (69.5); 178 (36); 164 (22); 162 (35); 150 (22); 144 (41); 134 (73); 118 (48); 117 (30); 114 (23); 106 (47); 102 (39); 90 (20); 86 (39); 74 (19); 72 (14); 71 (20); 70 (27); 59 (100); 56 (35); 45 (57)
<i>VI</i>	265 (42); 250 (99); 245 (25); 234 (40); 218 (21); 207 (10); 206 (100); 202 (10); 190 (10); 186 (22); 176 (25); 174 (12); 166 (14); 162 (72); 146 (31); 128 (12); 126 (17); 118 (50); 100 (12); 98 (11); 90 (15); 87 (11); 86 (18); 75 (16); 73 (17); 72 (20); 71 (15); 70 (11); 63 (13); 60 (14); 59 (77); 58 (80); 57 (12); 56 (55); 54 (11)
<i>VII</i>	246 (17); 225 (29); 217 (32); 183 (11); 176 (10); 160 (12); 146 (44); 118 (83); 113 (28); 100 (39); 72 (92); 71 (26); 69 (21); 59 (28); 58 (76); 56 (100); 55 (52)
<i>VIII</i>	191 (17); 176 (22); 160 (9); 100 (45); 92 (7); 91 (11); 72 (75); 71 (29); 70 (9); 63 (14); 60 (12); 59 (12); 58 (100); 56 (27); 44 (42)

Table I, for the IR spectrum of compound *II* see Table II, and for the mass spectrum of compound *IV* see Table III.

In the same manner the reaction carried out without solvent (methyl trifluoroacrylate 5.92 g, 42.2 mmol; diethylamine 1.73 g, 23.7 mmol) afforded a product which was distilled at 1 Torr. Fractions 62–65°C (0.41 g), 65–70°C (1.15 g), 70–76°C (0.62 g) had according to gas chromatography (20% poly(propylene sebacate), column length 120 cm, detection by ionisation) the following composition: The first fraction contained compounds *IV* and *VI* (52 and 48% rel.), the second fraction contained compounds *IV* and *VI* (19 and 79% rel.), and the third fraction contained compounds *VI*, *VII* and *VIII* (89, 8 and 3% rel.). The PMR spectrum of compound *IV* is given in Table I, for the mass spectrum of compound *VI* see Table III, and for the ultraviolet spectrum of *VII* see Table IV.

B. A solution of diethylamine (6.56 g; 90 mmol) in diethyl ether (30 ml) was added in the course of 30 minutes at 0°C to a mixture of methyl trifluoroacrylate (4.20 g; 30 mmol) and diethyl ether (100 ml) and the mixture was further stirred at 22°C for 4 hours. It was then evaporated to one half of its volume and silica gel powder (3 g) was added to it followed by methanol (3 g; 94 mmol), and the mixture was refluxed for 2 hours. After distillation off of the volatile components the residue (5.3 g) was distilled: fraction 84–92°C/0.25 Torr (3.65 g) contained compounds *VII* and *VIII* in relative amounts of about 35 and 65%. They were isolated by preparative gas chromatography on an analytical column (see *A.*). PMR spectra of compounds *VII* and *VIII* are given in Table I, the infrared spectra of both substances are in Table II, and for the mass spectra of both substances see Table III and for the ultraviolet spectrum of compound *VII* see Table IV. For compound *VII*, $C_{12}H_{23}FN_2O$ (246.2) calculated: 58.60% C, 9.35% H, 7.72% F, 11.40% N; found 57.67% C, 9.02% H, 8.16% F, 11.73% N. For compound *VIII*, $C_8H_{14}FNO_3$ (191.2) calculated: 50.28% C, 7.38% H, 9.93% F, 7.33% N; found: 50.62% C, 7.29% H, 9.46% F, 8.42% N.

Reaction of Methyl Trifluoroacrylate with Diisopropylamine

In the same manner as above (reaction *A*) methyl trifluoroacrylate (3.0 g, 21.4 mmol) was reacted with diisopropylamine (2.05 g; 20.2 mmol) in diethyl ether (20 ml). The residue (3.52 g) after evaporation of the volatile components at 0°C and 0.5 Torr contained approximately 85% of compound *V* and it was used for the measurement of the PMR spectrum (Table I), infrared spectrum (Table II) and ultraviolet spectrum (Table IV). A part of the residue (0.477 g) was dissolved in ether (4 ml) and methanol (2 ml) was added to the solution under stirring. After 20 hours reaction the mixture was diluted with trifluorotrichloroethane (15 ml), the mixture washed with water and dried over magnesium sulfate. Fractional distillation gave the following fractions:

TABLE IV

Ultraviolet Spectra of Compounds *I*, *IV*, *V* and *VII* (λ_{max} , nm)

Compound	<i>I</i> ^a	<i>IV</i> ^b	<i>V</i> ^a	<i>VII</i> ^b
$\pi\text{-}\pi^*$ λ_{max} (e)	207 (7 870)	214 (6 900)	209 (3 850)	215 (7 880)
$n\text{-}\pi^*$ λ_{max} (e)	244 (970)	276 (570)	274 (2 560)	307 (15 200)

^a Measured in cyclohexane; ^b in iso-octane.

60—66°C/0.2 Torr (0.12 g), and 66—67°C/0.2 Torr (0.15 g) which contained 89 and 97%, respectively, of compound IX (gas chromatography: poly(ethylene glycol) 400, 120 cm, 200°C). For the PMR spectrum of compound IX see Table I, for the infrared spectrum see Table II. For compound IX, $C_{10}H_{18}FNO_3$ (219.3) calculated: 54.95% C, 8.22% H, 8.67% F, 6.39% N; found: 54.59% C, 7.92% H, 8.62% F, 6.32% N.

The spectra were measured in the Departments of Infrared Spectrometry (head Dr P. Adámek), Mass Spectrometry and NMR Spectra (head Dr P. Trška), and elemental analyses were carried out in the Department of Organic Analysis (head Dr L. Helešic), Institute of Chemical Technology. We thank those mentioned for the analyses.

REFERENCES

1. Chambers R. D., Mobbs R. H.: *Advances in Fluorine Chemistry*, Vol. 4, p. 50. Butterworths, London 1965.
2. Paleta O.: Chem. listy 60, 1363 (1966).
3. Sheppard W. A., Sharts C. M.: *Organic Fluorine Chemistry*. Benjamin, New York 1969.
4. Pruett R. L., Barr J. T., Rapp K. E., Bahner C. T., Gibson J. D., Lafferty R. H.: J. Am. Chem. Soc. 72, 3646 (1950).
5. Cleaver C.S., England D. C.: US-Pat. 2 861 990 (1958); Chem. Abstr. 54, 14123 (1959).
6. England D. C., Melby R. L., Dietrich M. A., Lindsay R. V.: J. Am. Chem. Soc. 82, 5116 (1960).
7. Jarovenko N. N., Rakša M. A.: Ž. Obšč. Chim. 29, 2159 (1959).
8. Bergmann E. D., Cohen A. M.: Israel J. Chem. 8, 925 (1970).
9. Liška F.: Chem. listy 66, 189 (1972).
10. Paleta O., Koňárek J.: This Journal 38, 66 (1973).
11. Paleta O., Pošta A., Novotná Z.: This Journal 33, 2970 (1968).
12. Paleta O., Pošta A., Koňárek J.: Czechoslov. pat. 144 470 (1969).

Translated by Ž. Procházka.