molecule related by $x - {}^1/_2, {}^1/_2 - y, -z$.

related atom	atom	distance, Å
O1A	C16	3.35 (1)
O21	S1	3.49 (1)
O21	C1	3.26 (1)
O21	C2	3.29 (1)
O21′	S2	3.31 (1)
O21′	N1	3.42 (1)
O21′	C2	3.02 (1)
O21′	N2	3.30 (1)
O21′	C3	3.06 (1)

The O21 and O21′ contacts with A-ring carbons C1, C2, and C3 are less than the sum of their van der Waals radii.[16] The disorder observed in the O20–C21–O21 atoms is likely related to these close packing interactions.

Acknowledgment. We thank S. A. Mizsak for providing the 200-MHz ^{1}H NMR spectra and for help in their interpretation.

Registry No. **4**, 1164-91-6; **5a**, 92720-27-9; **5b**, 3701-62-0; **5c**, 92720-28-0; **5d**, 89396-38-3; **6**, 92720-29-1; **7**, 92720-30-4; **8**, 92762-53-3; **9**, 92720-31-5; **10**, 92720-32-6; **11**, 6971-92-2; (±)-**12**, 92720-33-7; **13**, 92720-34-8; **14**, 92720-35-9; **15**, 92720-36-0; **16**, 92720-37-1; (±)-**17**, 92720-38-2; **18**, 92762-54-4; **19**, 92720-39-3; **20**, 92720-40-6; **21**, 92720-41-7; **22**, 92720-42-8; **23**, 92720-43-9; (±)-norcamphor, 22270-13-9; cyclohexanone, 108-94-1; 3,3,5,5-tetramethylcyclohexanone, 14376-79-5; 17β-acetoxy-5α-estran-3-one, 33767-87-2; 4-*tert*-butylcyclohexanone, 98-53-3; 4,4-dimethylcyclohexanone, 4255-62-3; (ethoxycarbonyl)hydrazine, 4114-31-2; acetylhydrazine, 1068-57-1; formylhydrazine, 624-84-0; tosylhydrazine, 1576-35-8; thionyl chloride, 7719-09-7; ethyl chloroformate, 541-41-3.

Supplementary Material Available: Tables of anisotropic or isotropic thermal parameters, bond lengths, bond angles, and hydrogen coordinates for **6** (4 pages). Ordering information is given on any current masthead page.

Synthesis of 2*H*-1,4-Thiazine-2,6-dicarboxylates and Their Conversion to 3,4-Pyrroledicarboxylates via Sulfur Extrusion

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Received July 3, 1984

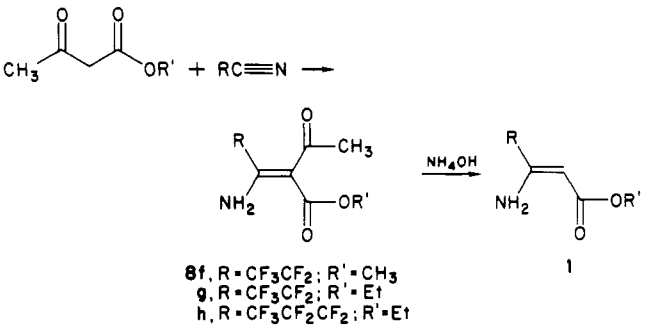
The reactions of 3-aminocinnamates **1c,d** with S_2Cl_2 provided 2,5-diaryl-3,4-pyrroledicarboxylates **7c,d** in 36–52% yields whereas the reactions of 3-(perfluoroalkyl)-3-aminoacrylates **1e–h** with S_2Cl_2 or SCl_2 gave 3,5-bis(perfluoroalkyl)-2*H*-1,4-thiazine-2,6-dicarboxylates **4e–h** as the major products. Further treatments of **4e–g** with triethylamine provided the corresponding pyrroles **7e–g** in good yields (58–77%) via sulfur extrusion. These methods constitute a novel synthesis of 3,4-pyrroledicarboxylates from 3-aminoacrylates.

Although 2*H*-1,4-thiazine was reported[1] in 1948, only limited methods have been developed for the synthesis of this ring system and only a few 2*H*-1,4-thiazinecarboxylates are known.[2] Contrarily, the chemistry of the corresponding dihydro-1,4-thiazines has been well developed.[2] Because several biologically active and naturally occurring compounds contain the 1,4-thiazine ring,[2] we are interested in developing new synthetic methodology for this chemical class, particularly the hitherto unknown 2*H*-1,4-thiazine-2,6-dicarboxylates **4**.

In principle **4** might be prepared by reaction of 3-aminoacrylates **1** with S_2Cl_2 or SCl_2 to form bis(2-aminovinyl) sulfides **2** first, followed by cyclization of **2** to 3-amino-2,3-dihydro-2*H*-1,4-thiazine-2,6-dicarboxylates **3** and loss of ammonia from **3** as shown in Scheme I. The reactions of 3-aminocrotonates with S_2Cl_2 and SCl_2 have been reported[3] to give unsatisfactory results in attempts to prepare the corresponding **2a**. However, **2a** has been obtained from the reaction of methyl 3-aminocrotonate (**1a**) with morpholine-*N*-sulfenyl chloride.[3] No further transformation of **2a** has been reported. We have prepared **2b** from **1b** similarly but have been unable to cyclize **2b** under a variety of conditions. We thought that the cyclization process might be facilitated by replacement of the 3-methyl group in **2b** with an electron-withdrawing group such as an aryl or a perfluoroalkyl group and decided to study the reactions of S_2Cl_2 and SCl_2 with 3-aminoacrylates containing electron-withdrawing substituents.

Results and Discussion

The starting 3-aminocinnamates **1c,d** were prepared from the appropriate Grignard reagent and ethyl cyanoacetate as described previously.[4] The 3-(perfluoroalkyl)-3-aminoacrylates **1e–h** were prepared either by the reaction of the appropriate 3-keto ester with ammonia[5] or by reaction of an acetoacetate with an appropriate perfluoroalkanenitrile[6] followed by treatment of the resulting adduct with ammonium hydroxide.



(1) Barkenbus, C.; Landis, P. S. *J. Am. Chem. Soc.* **1948**, *70*, 684.
(2) For a review of 2*H*-1,4-thiazines see: Stoodley, R. J. In "Advances in Heterocyclic Chemistry"; Katritzky, A. R., Boulton, A. J., Eds.; Academic Press: New York, 1979; Vol. 24, pp 293–361.
(3) Gompper, R.; Euchner, H.; Kast, H. *Liebigs Ann. Chem.* **1964**, *675*, 151.
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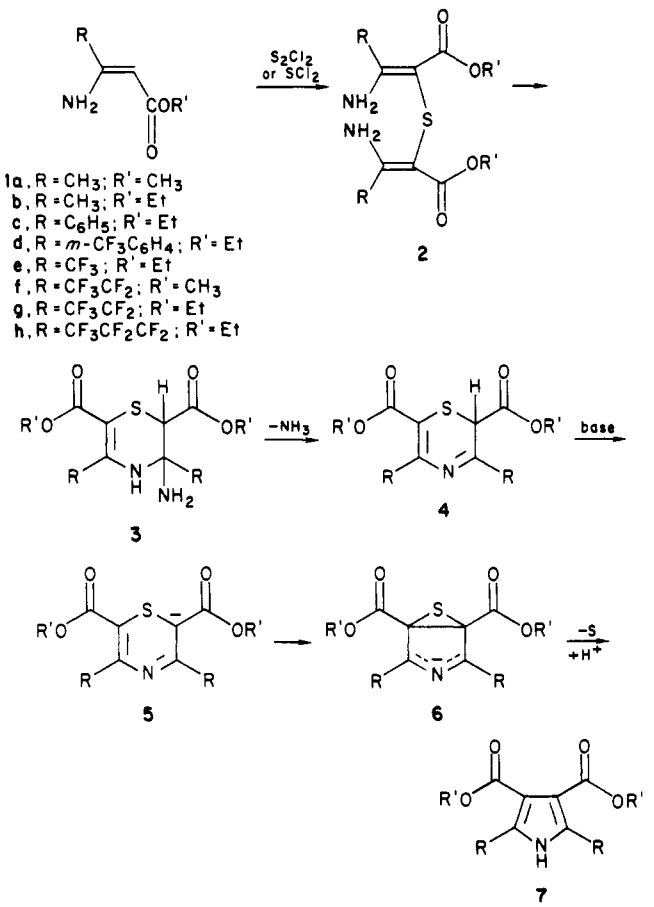
(6) Bodnarchuk, N. D.; Gavrilenko, B. B.; Derkach, G. I. *J. Org. Chem. U.S.S.R.* **1968**, *4*, 1645 and references cited therein.

0022-3263/84/1949-4780$01.50/0

Scheme I



We found that addition of 1 equiv of S_2Cl_2 to 2 equiv of 3-aminocinnamates **1c,d** in chlorobenzene followed by a brief period of reflux produced diethyl 2,5-diaryl-3,4-pyrroledicarboxylates **7c,d** in 36–52% yields; no amounts of the expected 2*H*-1,4-thiazines **4c,d** were detected. We believe that **4c,d** were produced initially in the reactions but were converted to **7c,d** by the basic **1c,d** via facile sulfur extrusion as shown in Scheme I. The less basic ethyl 3-amino-4,4,4-trifluorocrotonate (**1e**), on the other hand, gave **4e** as the major product (**51%**) and **7e** as the minor product (7%) under similar conditions. We found SCl_2 to be a better reagent than S_2Cl_2 since SCl_2 produces less elemental sulfur as byproduct. We further found that the yields of the desired **4e–h** could be improved substantially by inverse addition; addition of SCl_2 to **1h** produced **4h** in 28% yield and **7h** in 17% yield, but the inverse addition of **1h** to SCl_2 produced **4h** in 71% yield (isolated) and only a very little amount (<4%) of pyrrole **7h** was detected in the crude product mixture. Other 2*H*-1,4-thiazines **4e–g** also were obtained in good yields (60–80%) under the inverse addition condition.

Intermediates which decomposed to **4** upon prolonged stirring or heating were detected by GC during the reaction of **1e–h** with S_2Cl_2 or SCl_2. We believe these intermediates are **3e–h**. Although the pentafluoroethyl and heptafluoropropyl analogues **3f–h** were too unstable to be isolated, we did succeed in isolation of the trifluoromethyl analogue **3e** from a reaction mixture of **1e** and SCl_2 in cold ether. The exact stereochemistry of **3e** is unknown, but **3e** was determined to be a single isomer based on its ^1H, ^{13}C, and ^{19}F NMR spectral data. This compound is unstable toward heat, as expected, and brief heating of **3e** in a mixture of chloroform and hexane caused considerable decomposition to **4e**; **3e** also converted to **7e** instantly upon dissolution in Me_2SO-d_6.

The reactions of **4e–g** with triethylamine in ether at reflux produced the pyrroles **7e–g** in 58–77% yields. Without purification of the intermediate **4e**, we obtained **7e** from **1e** in 56% yield overall by using this two-step synthesis. Addition of triethylamine to a solution of **4e** in ether at −40 °C resulted instantly in a dark blue color which persisted at low temperature. The solution changed from blue to yellow upon warming. This yellow solution gave **7e** (58% yield) after workup. We attribute this dark blue color to the presence of either anion **5** or **6** (Scheme I) which extrudes sulfur upon warming. Extrusion of sulfur from the 2*H*-1,4-thiazine system under such mild conditions is unprecedented, although extrusion of sulfur from alkyl thioimidates has been well utilized in organic synthesis.[7]

The above described methods constitute a convenient synthesis of 2,5-diaryl- and 2,5-bis(perfluoroalkyl)-3,4-pyrroledicarboxylates. The 2,5-diaryl-3,4-pyrroledicarboxylates have been prepared by the Knorr pyrrole synthesis,[8] by cycloadditions of dimethyl acetylenedicarboxylate to mesoionic oxazolones[9] and to nitrile ylides,[10–12] and by oxidation of (*N*-alkyl-3-amino)cinnamates with lead tetraacetate,[13] but the 2,5-bis(perfluoroalkyl) analogues have not been synthesized previously. Our attempts to prepare these analogues by the Knorr pyrrole synthesis were unsuccessful.

Experimental Section

Melting points were determined with a Laboratory Devices Mel-Temp apparatus and are uncorrected. ^1H NMR spectra were recorded on Varian T-60 (60 MHz) and Varian EM-360L (60 MHz) spectrometers. ^{13}C NMR spectra were measured at 25.05 MHz with a JEOL FX-100 spectrometer. ^{19}F NMR spectra were obtained with a Varian EM-390 (90 MHz) spectrometer. ^1H NMR and ^{13}C NMR spectra were recorded in $CDCl_3$ unless otherwise noted and are expressed in parts per million (ppm) downfield from Me_4Si; the C–F coupling constants are expressed as $^nJ_{CF}$ where n is the number of bonds between carbon and fluorine; couplings are in hertz. ^{19}F NMR spectra were recorded in $CDCl_3$ with benzotrifluoride (δ −63.73) in a sealed capillary as an external standard and are expressed in ppm relative to CCl_3F, with upfield shifts taken as negative. Mass spectra were determined with a Varian Mat 311 A instrument operating on either electron-impact (EI) or field-ionization (FI) mode. IR spectra were recorded on a Perkin-Elmer 727 B spectrometer. Gas chromatography (GC) was performed on a Perkin-Elmer gas chromatograph with a 2 ft X 0.25 in. column packed with 10% OV 17 on 80/100 chromosorb W. Column chromatography (CC) was performed with 60–200 μm silica gel 60 (EM Reagents). Preparative medium-pressure liquid chromatography (MPLC) was done on a EM LOBAR size C silica gel column. Elemental analysis were performed by Atlantic Microlab, Inc. Atlanta, GA. Unless otherwise noted, the organic layers were dried over $MgSO_4$ and concentrated in vacuo with a Buchi rotary evaporator. The flash distillations were performed by using a Kugelrohr distillation apparatus and the recorded temperature for a specific fraction was the temperature of the Kugelrohr pot. The 3-aminocinnamates **1c,d** were prepared as described previously.[4] Ethyl 3-amino-4,4,4-trifluorocrotonate (**1e**) was prepared from ethyl trifluoroacetoacetate by a reported procedure.[5]

Bis(2-amino-1-(ethoxycarbonyl)propen-1-yl) Sulfide (2b).

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(9) Bayer, H. O.; Gotthardt, H.; Huisgen, R. *Chem. Ber.* **1970**, *103*, 2356.
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The reaction of **1b** with morpholine-*N*-sulfenyl chloride by a procedure similar to that reported by Gompper et al.[3] for the preparation of **2a** provided a solid (43% yield), mp 124–134 °C, which after successive recrystallization from acetone and ethanol gave **2b**, mp 143–148 °C, containing a mixture of geometric isomers: ^{1}H NMR (Me_2SO-d_6) δ 7.1, 7.7, 8.0 (three br s, total 4 H), 3.8–4.4 (m, total 4 H), 2.30, 2.23, 2.20 (three s, total 6 H), 1.0–1.4 (m, total 6 H).

Anal. Calcd for $C_{12}H_{20}N_2O_4S$: C, 49.99; H, 6.99; N, 9.72. Found: C, 50.04; H, 7.02; N, 9.68.

Attempted cyclizations of **2b** under a variety of conditions were unsuccessful.

General Procedure (A) for 2-Acetyl-3-(perfluoroalkyl)-3-aminoacrylates 8f–h. A modified procedure of Bodnarchuk et al.[6] was employed. Into a well stirred mixture of 0.5–0.6 mol of alkyl acetoacetate, 100 mL of saturated NaOAc, and 200 mL of an appropriate alcohol at 50–60 °C was passed 0.3–0.9 mol of an appropriate perfluoroalkanenitrile gas during a 2.5-h period. The reaction mixture was cooled and poured into saturated NaCl solution. The organic layer was extracted into ether. The ether solution was dried and concentrated, and the residue was distilled through a Vigreux column under reduced pressure to give the desired **8f–h** which contained a mixture of two geometric isomers.

Methyl 2-Acetyl-3-amino-4,4,5,5,5-pentafluoro-2-pentenoate (8f). The crude product from the reaction of methyl acetoacetate and pentafluoropropionitrile was distilled at 1.5 torr to give 58.4 g (37% based on methyl acetoacetate) of **8f** (bp 67–75 °C), which crystallized after cooling: mp 49–67 °C; ^{1}H NMR 6.9–8.3 (br, 2 H), 3.80 (s, 3 H), 2.37 and 2.20 (two s, total 3 H).

Anal. Calcd for $C_8H_8F_5NO_3$: C, 36.79; H, 3.09; N, 5.36. Found: C, 36.64; H, 3.10; N, 5.35.

Ethyl 2-Acetyl-3-amino-4,4,5,5,5-pentafluoro-2-pentenoate (8g). The crude product from the reaction of ethyl acetoacetate and pentafluoropropionitrile was distilled at 1.5 torr to give 34 g (38% based on pentafluoropropionitrile) of **8g**: bp 83–85 °C; n^{25}_D 1.4363; ^{1}H NMR δ 7.4 (br, 2 H), 4.3 (q, J = 7, 2 H), 2.26 and 2.40 (two s, total 3 H), 1.33 (t, J = 7, 3 H).

Anal. Calcd for $C_9H_{10}F_5NO_3$: C, 39.28; H, 3.66; N, 5.09. Found: C, 38.84; H, 3.67; N, 4.90.

Ethyl 2-Acetyl-3-amino-4,4,5,5,6,6,6-heptafluoro-2-hexenoate (8h). The crude product from the reaction of ethyl acetoacetate with heptafluorobutyronitrile was distilled at 1 torr to give 74.6 g (67% based on heptafluorobutyronitrile) of **8h**: bp 88–95 °C; n^{25}_D 1.4209; ^{1}H NMR δ 6.9 and 8.1 (two br s, total 2 H), 4.23 (q, J = 7, 2 H), 2.37 and 2.36 (two s, total 3 H), 1.33 (t, J = 7, 3 H).

Anal. Calcd for $C_{10}H_{10}F_7NO_3$: C, 36.90; H, 3.01; N, 4.30. Found: C, 36.53; H, 3.08; N, 4.23.

General Procedure (B) for 3-(Perfluoroalkyl)-3-aminoacrylates 1f–h. A mixture of 0.08–0.20 mol of **8**, 75–150 mL of ammonium hydroxide, and 20 mL of ether was stirred for 64 h. The reaction mixture was extracted with ether. The ether extract was dried and concentrated. The residue was distilled under reduced pressure to give the desired **1f–h**.

Methyl 3-Amino-4,4,5,5,5-pentafluoro-2-pentenoate (1f). Distillation of the crude product from **8f** at 9 torr provided pure **1f** (78%): bp 54–59 °C; n^{25}_D 1.3974; ^{1}H NMR δ 6.4 (br, 2 H), 5.20 (s, 1 H), 3.77 (s, 3 H).

Anal. Calcd for $C_6H_6F_5NO_2$: C, 32.89; H, 2.76; N, 6.39. Found: C, 32.83; H, 2.78; N, 6.39.

Ethyl 3-Amino-4,4,5,5,5-pentafluoro-2-pentenoate (1g). The crude reaction product from **8g** was distilled to give **1g** (72%): bp 64–69 °C (6 torr); n^{25}_D 1.4029; ^{1}H NMR δ 6.5 (br, 2 H), 5.13 (s, 1 H), 4.23 (q, J = 7, 2 H), 1.30 (t, J = 7, 3 H).

Anal. Calcd for $C_7H_8F_5NO_2$: C, 36.06; H, 3.46; N, 6.01. Found: C, 35.87; H, 3.12; N, 5.98.

Ethyl 3-Amino-4,4,5,5,6,6,6-heptafluoro-2-hexenoate (1h). The crude product from **8h** was worked up as described above to give a colorless liquid (92%): mp 70–71 °C (8 torr); n^{25}_D 1.3875; ^{1}H NMR δ 6.37 (br, 2 H), 5.10 (s, 1 H), 4.20 (q, J = 7, 2 H), 1.27 (t, J = 7, 3 H).

Anal. Calcd for $C_8H_8F_7NO_2$: C, 33.93; H, 2.85; N, 4.95. Found: C, 34.15; H, 2.87; N, 4.98.

Diethyl 2,5-Diphenyl-3,4-pyrroledicarboxylate (7c). To a cold (10 °C) solution of 10.3 g (0.0539 mol) of **1c** in 20 mL of chlorobenzene was added 3.64 g (0.0269 mol) of S_2Cl_2 in 2 min. The reaction mixture was held at 135 °C for 3 h, cooled, and filtered to give 6.8 g of solid. This solid was washed with water to give 5.2 g of material which was stirred with hot ether and filtered. The ether insoluble material was stirred with chloroform and filtered to remove 0.24 g of sulfur. The combined ether–chloroform filtrates were concentrated and the residue was recrystallized from chloroform–hexane to give 3.37 g (34%) of **7c**: mp 148–150 °C (lit.[8] mp 151–152 °C); ^{1}H NMR δ 9.33 (s, 1 H), 7.0–7.6 (m, 10 H), 4.07 (q, J = 7.0, 4 H), 1.13 (t, J = 7.0, 6 H); MS, m/e (relative intensity) 363 (56), 335 (8), 318 (19), 307 (11), 306 (13), 291 (31), 290 (95), 279 (8), 278 (9), 272 (18), 263 (22), 246 (100), 245 (82), 244 (19).

Anal. Calcd for $C_{22}H_{21}NO_4$: C, 72.71; H, 5.83; N, 3.86. Found: C, 72.67; H, 5.83; N, 3.83.

The chlorobenzene filtrate was concentrated and the residue was worked up as described above to give an additional 1.7 g (17%) of **7c**, mp 149–151 °C.

Diethyl 2,6-Bis(α,α,α-trifluoro-*m*-tolyl)-3,4-pyrroledicarboxylate (7d). To a cold (10 °C) solution of 11.9 g (0.0459 mol) of **1d** in 20 mL of chlorobenzene was added dropwise 3.10 g (0.0230 mol) of S_2Cl_2. The reaction mixture was stirred at 135 °C for 2 h, cooled, and filtered. The filtered cake was washed with ether to give 2.6 g of solid which was washed with water to give 1.7 g of yellow solid. This material was stirred with hot ether and filtered to remove 0.5 g of sulfur. The ether filtrate was concentrated and the residue was recrystallized from ether–hexane to give 0.7 g (6%) of **7d**: mp 126–127 °C; ^{1}H NMR δ 8.87 (s, 1 H), 7.2–8.8 (m, 8 H), 4.13 (q, J = 7.0, 4 H), 1.2 (t, J = 7.0, 6 H); MS (FI mode), m/e 499 (M^+).

Anal. Calcd for $C_{24}H_{19}F_6NO_4$: C, 57.72; H, 3.83; N, 2.81. Found: C, 57.72; H, 3.87; N, 2.79.

The original chlorobenzene–ether filtrate was concentrated and the residue was purified as described above to give an additional 3.41 g (30%) of **7d**, mp 126–127 °C.

Reaction of 1e with S_2Cl_2 or SCl_2; Isolation of Diethyl 3,5-Bis(trifluoromethyl)-2*H*-1,4-thiazine-2,6-dicarboxylate (4e). (a) Addition of S_2Cl_2 to 1e. To a solution of 36.6 g (0.20 mol) of **1e** in 30 mL of chlorobenzene was added dropwise 13.5 g (0.10 mol) of S_2Cl_2 in 10 min (exothermic reaction). The mixture was held at reflux for 30 min, cooled to 35 °C, and kept at 35 °C for 62 h. The white and yellow precipitates were filtered. The white precipitate appeared to be ammonium chloride (soluble in water). The yellow precipitate was sulfur. The filtrate was concentrated and the residue was flash distilled (1 torr, 130 °C) to give 31.4 g of a mixture of oil and solid. This mixture was stirred with petroleum ether (30–75 °C) and filtered to remove sulfur. The filtrate was concentrated and the residue was chromatographed (CC, 19:1 petroleum ether:EtOAc). The first fraction was 0.5 g of sulfur. The second fraction was 19.4 g (51%) of **4e**: n^{25}_D 1.4395; ^{1}H NMR δ 4.59 (s, 1 H), 4.38 and 4.22 (two overlapped q, J = 7, 4 H), 1.37 and 1.23 (two overlapped t, J = 7, 6 H); ^{13}C NMR δ 163.9, 162.2, 138.4, ($^2J_{CF}$ = 38.3), 134.5 ($^2J_{CF}$ = 37.5), 124.6, 120.1 ($^1J_{CF}$ = 273.5), 118.9 ($^1J_{CF}$ = 277.2), 63.8, 34.9, 13.8; ^{19}F NMR δ −63.18 (s, 3 F), −70.10 (s, 3 F); IR (film) 1740 cm^{-1}; MS, m/e (relative intensity) 379 (4), 307 (65), 306 (62), 279 (42), 278 (61), 259 (17), 234 (96), 69 (100).

Anal. Calcd for $C_{12}H_{11}F_6NO_4S$: C, 38.00; H, 2.92; N, 3.69; S, 8.46. Found: C, 37.85; H, 2.98; N, 3.69; S, 8.33.

The third fraction was 4.4 g of an oil which was a mixture of **4e** and **7e**. The fourth fraction was 3.5 g (10%) of an oil which after crystallization from petroleum ether at low temperature gave 2.3 g (7%) of a solid, mp 44–53 °C, which was essentially identical to **7e** (vide infra) based on ^{1}H and ^{13}C NMR spectra.

(b) Addition of 1e to SCl_2. To a cold (0 °C) solution of 9.3 g (0.091 mol) of SCl_2 in 40 mL of hexane and 40 mL of ether was added 29.2 g (0.16 mol) of **1e** in 20 min. The reaction mixture was held at reflux for 64 h and filtered. The filtrate was concentrated and the residue was chromatographed (MPLC, 4:1 cyclohexane:EtOAc) to give 23.9 g (78%) of **4e**.

Diethyl 3-Amino-3,5-bis(trifluoromethyl)-3,4-dihydro-2*H*-1,4-thiazine-2,6-dicarboxylate (3e). To a cold (10 °C) solution of 10.3 g (0.1 mol) of SCl_2 in 50 mL of ether was added a solution of 36.8 g (0.2 mol) of **1e** in 20 mL of ether in 50 min. The reaction mixture was stirred for 1 h and poured slowly into 200 mL of saturated aqueous $NaHCO_3$. The ether layer was separated, dried, and concentrated. The residual oil was triturated with petroleum

ether to give 19 g (48%) of **3e**, mp 87.5–92 °C. Recrystallization ($CHCl_3$–hexane) gave 8.14 g of **3e**, mp 88.5–92 °C; ^1H NMR δ 4.99 (br s, 1 H), 4.17 (q, J = 7, 4 H), 3.77 (s, 1 H), 2.33 (br s, 2 H), 1.27 (t, J = 7, 6 H); ^{19}F NMR δ −62.80 (s, 3 F), −79.81 (s, 3 F); ^{13}C NMR δ 166.9, 162.8, 132.0 (q, $^2J_{CF}$ = 35.0), 123.6 (q, $^1J_{CF}$ = 287), 120.0 (q, $^1J_{CF}$ = 272), 69.4 (q, $^2J_{CF}$ = 30), 62.6, 62.1, 42.0, 13.8.

Anal. Calcd for $C_{12}H_{14}F_6N_2O_4S$: C, 36.36; H, 3.56; N, 7.07; S, 8.09. Found: C, 36.37; H, 3.59; N, 7.07; S, 8.07.

The mother liquor was concentrated to give 9.9 g of an oil which was mainly **4e** (^1H NMR). The ^1H and ^{13}C NMR of a solution of **3e** in Me_2SO-d_6 indicated that **3e** was completely converted to **7e**.

General Procedure (C) for 3,5-Bis(perfluoroalkyl)-2*H*-1,4-thiazine-2,6-dicarboxylates 4f,g. To a cold (−2 to 5 °C) solution of SCl_2 (0.02–0.06 mol) in 20–100 mL of chlorobenzene was added a solution of 2 equiv of **1f–g** in 10 mL of chlorobenzene in 10 min. The reaction mixture was held at 50–55 °C for 4 h and filtered. The filtrate was concentrated and the residue was purified by flash distillation and/or recrystallization.

Dimethyl 3,5-Bis(pentafluoroethyl)-2*H*-1,4-thiazine-2,6-dicarboxylate (4f). The reaction of 5.9 g (0.0573 mol) of SCl_2 and 24.7 g (0.113 mol) of **1f** gave 24.1 g of crude product which was flash distilled (1.5 torr, 90–110 °C) to give 16.6 g of solid. Recrystallization (petroleum ether) at low temperatures gave 15.5 g (60%) of solid: mp 33.5–36 °C; ^1H NMR δ 4.63 (s, 1 H), 3.93 (s, 3 H), 3.76 (s, 3 H).

Anal. Calcd for $C_{12}H_7F_{10}NO_4S$: C, 31.94; H, 1.56; N, 3.10; S, 7.11. Found: C, 31.91; H, 1.58; N, 3.10; S, 7.03.

Diethyl 3,5-Bis(pentafluoroethyl)-2*H*-1,4-thiazine-2,6-dicarboxylate (4g). The crude product from the reaction of 2.1 g (0.02 mol) of SCl_2 and 9.3 g (0.04 mol) of **1g** was flash distilled (1 torr, 110 °C) to give 7.96 g (83%) of an oil: n^{25}_D 1.4140; ^1H NMR δ 4.56 (s, 1 H), 4.33 and 4.20 (two q, J = 8, 4 H), 1.33 and 1.22 (two t, J = 8, 6 H); MS, m/e (relative intensity) 479 (1), 407 (30), 406 (42), 379 (18), 378 (24), 359 (19), 334 (48), 226 (11), 265 (30), 214 (11), 196 (12), 169 (12), 119 (55), 45 (100).

Anal. Calcd for $C_{14}H_{11}F_{10}NO_4S$: C, 35.08; H, 2.31; N, 2.92. Found: C, 35.39; H, 2.15; N, 2.96.

Diethyl 3,5-Bis(heptafluoropropyl)-2*H*-1,4-thiazine-2,6-dicarboxylate (4h) and Diethyl 2,5-Bis(heptafluoropropyl)-3,4-pyrroledicarboxylate (7h). (a) Addition of SCl_2 to 1h. To a cold (2 °C) solution of 17.0 g (0.06 mol) of **1h** in 30 mL of chlorobenzene was added 3.06 g (0.03 mol) of SCl_2 in 10 min. The reaction mixture was allowed to warm to room temperature in 30 min and triturated with 200 mL of hexane. The hexane–chlorobenzene solution was cooled with a Dry Ice bath. The insoluble material was filtered to give 8.2 g of solid. This solid was dissolved in ether and the ether solution was washed with water, dried, and concentrated to give 7.0 g of an oil which contained a 1:1 mixture of **4h** and **7h** (GC analysis). Part (5.3 g) of this oil was chromatographed (MPLC, 92:8 petroleum ether:EtOAc). The first fraction was 1.92 g (11%) of **7h**: mp 70.5–73.5 °C; ^1H NMR δ 4.35 (q, J = 7, 4 H), 1.33 (t, J = 7, 6 H); IR ($CHCl_3$) 3400, 3300–2800, 1730 cm^{-1}.

Anal. Calcd for $C_{16}H_{11}F_{14}NO_4$: C, 35.11; H, 2.03; N, 2.56. Found: C, 35.41; H, 2.07; N, 2.58.

The second fraction was 2.0 g (11%) of **4h** as an oil: n^{25}_D 1.4011; ^1H NMR δ 4.57 (s, 1 H), 4.40 and 4.27 (two q, J = 7, 4 H), 1.33 and 1.23 (two t, J = 7, 6 H), IR (film) 1730 cm^{-1}.

Anal. Calcd for $C_{16}H_{11}F_{14}NO_4S$: C, 33.17; H, 1.91; N, 2.42. Found: C, 33.32; H, 1.81; N, 2.36.

The original hexane–chlorobenzene filtrate was concentrated to give 9.0 g of an oil which after workup as described above yielded an additional 1.0 g (6%) of **7h** and 2.5 g (14%) of **4h**.

(b) Addition of 1h to SCl_2. To a cold (0 °C) solution of 2.1 g (0.02 mol) of SCl_2 in 10 mL of chlorobenzene was added a solution of 11.3 g (0.04 mol) of **1h** in 10 mL of chlorobenzene in 10 min. The reaction mixture was stirred for 5 days and filtered. The reaction mixture was concentrated to 12.0 g of an oil which contained a 30:1 mixture of **4h** and **7h**. Purification of this oil by MPLC as described above gave 8.2 g (71%) of **4h**.

General Procedure (D) for Diethyl 2,5-Bis(perfluoroalkyl)-3,4-pyrroledicarboxylates 7. To a solution of 0.009–0.016 mol of **4** in 20 mL of ether was added an equimolar of triethylamine. The reaction mixture was held at reflux for 1 h and filtered. The filtrate was washed with diluted HCl, dried, and concentrated. The residue was chromatographed to give an oil which was purified by crystallization from petroleum ether at low temperature.

Diethyl 2,5-Bis(trifluoromethyl)-3,4-pyrroledicarboxylate (7e). (a) From the Reaction of 4e with Triethylamine. The crude product from the reaction of 3.8 g (0.01 mol) of **4e** with 1.0 g (0.01 mol) of triethylamine was chromatographed (CC, 19:1 petroleum ether:EtOAc) to give 2.3 g of oil which was crystallized to give 2.0 g (57%) of solid: mp 55–57 °C; ^1H NMR δ 10.67 (br s, 1 H), 4.37 (q, J = 7, 4 H), 1.30 (t, J = 7, 6 H); ^{19}F NMR δ −59.36 (s); ^{13}C NMR δ 162.3, 122.5 (q, $^2J_{CF}$ = 41.2), 119.2 (q, $^1J_{CF}$ = 269.1), 118.2 (q, $^3J_{CF}$ = 1.2), 62.2, 13.8; IR (CCl_4) 3420–3200, 1720 cm^{-1}; MS, m/e (relative intensity) 347 (3), 302 (17), 275 (100), 234 (57), 69 (62).

Anal. Calcd for $C_{12}H_{11}F_6NO_4$: C, 41.51; H, 3.19; N, 4.03. Found: C, 41.51; H, 3.19; N, 4.01.

(b) Reaction of 4e with Triethylamine at −40 °C. To a cold (−40 °C) solution of 3.79 g (0.01 mol) of **4e** in 30 mL of ether was added dropwise 1.01 g (0.01 mol) of triethylamine. A dark blue color developed after a few drops of triethylamine was added. The blue color persisted after complete addition of triethylamine. The reaction mixture was warmed to 15 °C in 30 min. The blue color changed to yellow. The reaction mixture was concentrated at 17 °C to give 4.2 g of residue which was dissolved in $CHCl_3$ and filtered. The filtrate was washed with diluted HCl, dried, and concentrated. The residue was worked up as described above to give 2.0 g (57%) of **7e**.

(c) Two-Step Synthesis from 1e. A mixture of 183 g (1.0 mol) of **1e** and 53 g (0.50 mol) of SCl_2 in 250 mL of chlorobenzene was reacted at 100 °C for 10 h and worked up by the general procedure C. The crude product was flash distilled (1.5 torr, 120 °C). The distillate (152 g) was further distilled at 3 torr through a 25-cm Vigreux column to remove 13.3 g of a forerun (bp 55–110°). The residue (133 g) was treated with 35 g (0.346 mol) of triethylamine (exothermic reaction). The mixture was stirred for 30 min and triturated with 500 mL of ether and 300 mL of 6 N HCl and filtered to remove 7.6 g of sulfur. The ether layer was dried and concentrated. The residue was flash distilled (1 torr, 150 °C) to give 122 g of distillate which was chromatographed (CC, 3:1 petroleum ether:ether) to give an oil. Crystallization of this oil from petroleum ether gave 96.7 g (56% from **1e**) of **7e**.

Dimethyl 2,5-Bis(pentafluoroethyl)-3,4-pyrroledicarboxylate (7f). The crude product from the reaction of 7.0 g (0.0155 mol) of **4f** and 1.57 g (0.0155 mol) of triethylamine was flash distilled (1.5 torr, 120 °C) to give 6.25 g of an oil which was chromatographed (CC, 3:2 petroleum ether:ether) to give 5.1 g of solid. Recrystallization (petroleum ether) gave 4.96 g (77%) of **7f**: mp 68–71 °C; ^1H NMR δ 3.92 (s).

Anal. Calcd for $C_{12}H_7F_{10}NO_4$: C, 34.46; H, 1.69; N, 3.35. Found: C, 34.36; H, 1.71; N, 3.34.

Diethyl 2,5-Bis(pentafluoroethyl)-3,4-pyrroledicarboxylate 7g. The crude product from the reaction of **4g** (4.36 g, 0.0091 mol) and triethylamine (0.92 g, 0.0091 mol) was chromatographed (CC, CH_2Cl_2) to give 3.5 g of an oil which was crystallized to give 2.54 g (63%) of solid: mp 64.5–65.5 °C; ^1H NMR δ 10.2 (br, 1 H), 4.33 (q, J = 7, 4 H), 1.30 (t, J = 7, 6 H).

Anal. Calcd for $C_{14}H_{11}F_{10}NO_4$: C, 37.60; H, 2.48; N, 3.13. Found: C, 37.93; H, 2.28; N, 3.15.

Registry No. **1c**, 33831-72-0; **1d**, 68210-91-3; **1e**, 372-29-2; **1f**, 87613-27-2; **1g**, 72850-56-7; **1h**, 87613-26-1; **3e**, 87613-25-0; **4e**, 87613-21-6; **4f**, 87613-23-8; **4g**, 87613-20-5; **4h**, 87613-22-7; **7c**, 66092-09-9; **7d**, 92844-44-5; **7e**, 88149-57-9; **7f**, 88149-58-0; **7g**, 88149-55-7; **7h**, 88149-56-8; (*E*)-**8f**, 92844-42-3; (*Z*)-**8f**, 92900-52-2; (*E*)-**8g**, 92844-43-4; (*Z*)-**8g**, 92844-45-6; (*E*)-**8h**, 92900-51-1; (*Z*)-**8h**, 92844-46-7; $CH_3COCH_2COOCH_3$, 105-45-3; CH_3COCH_2COOEt, 141-97-9; CF_3CF_2CN, 422-04-8; $CF_3(CF_2)_2CN$, 375-00-8; S_2Cl_2, 10025-67-9; SCl_2, 10545-99-0.