benzene (50 mL) and α-bromophenylacetic acid (4.3 g, 20 mmol) was treated dropwise with Et_3N (2.02 g, 20 mmol) and stirred for 6 h at room temperature. Insoluble material was filtered and the filtrate was diluted with $CHCl_3$, washed with H_2O (2 × 20 mL), dried (Na_2SO_4), and concentrated. Addition of benzene gave 2-quinolinyl-2-phenylthioglycolic acid (**1**, R = Ph) as a colorless solid which crystallized from $CHCl_3$–benzene as colorless prisms: mp 140 °C dec; IR (KBr) 1705 cm^{-1} (CO); NMR (Me_2SO-d_6) δ 8.21–7.28 (m, 11, aromatic), 5.85 (s, 1, CH). Anal. Calcd for $C_{17}H_{13}NO_2S$: C, 69.11; H, 4.43; N, 3.74. Found: C, 69.36; H, 4.42; N, 4.73.

The above acid (2.0 g, 7 mmol) in anhydrous benzene (2 mL) was treated with a mixture of Ac_2O (4 mL) and Et_3N (4 mL) and stirred for 1 h at room temperature. Addition of anhydrous Et_2O precipitated a deep-red solid that crystallized from $CHCl_3$–Et_2O as deep-red plates: 88%; mp 198–199 °C dec, identical[9] with that prepared above.

Reaction of *anhydro*-1-Hydroxy-2-phenylthiazolo[3,2-*a*]quinolinium Hydroxide (2, R = Ph) with Dimethyl Acetylenedicarboxylate. The above mesoionic compound (0.81 g; 3 mmol), dimethyl acetylenedicarboxylate (0.5 g; 35.2 mmol), and toluene (30 mL) were refluxed for 6 h. Evaporation of the toluene in vacuo and trituration of the residue with hot EtOH gave a yellow solid that crystallized from $CHCl_3$–EtOH as yellow needles of methyl 1-phenylpyrrolo[1,2-*a*]quinoline-2,3-dicarboxylate (**9**, R = R^1 = $COOCH_3$): 66%; mp 160–161 °C (lit.[6] mp 161–162 °C); IR (KBr) 1725, 1705 cm^{-1}; λ_{max} (CH_3OH) 350 (log ε 4.06), 277 (4.03), 227 nm (sh, 4.39); NMR ($CDCl_3$) δ 8.28–7.16 (m, 11, aromatic), 3.91 (s, 3, $COOCH_3$), 3.71 (s, 3, $COOCH_3$); M^+· 359 (100). Anal. Calcd for $C_{22}H_{17}NO_4$: C, 73.53; H, 4.77; N, 3.90. Found: C, 73.68; H, 4.64; N, 3.76.

In one experiment dry N_2 was passed through the reaction mixture and the effluent gases condensed in an alcoholic solution of piperidine. Concentration of this solution resulted in colorless needles of *N,N'*-pentamethylenethiocarbamic acid, recrystallized from acetone, mp 112–113 °C (lit.[10] mp 113–115 °C), identical[9] with an authentic sample.

Ethyl 1-phenylpyrrolo[1,2-*a*]quinoline-3-carboxylate (9, R = H; R^1 = COOEt) was obtained as yellow needles from $CHCl_3$–EtOH from **2** (R = Ph) and ethyl propiolate in refluxing toluene over 7 h: 95%; mp 98 °C; IR (KBr) 1700 (CO), 1660 cm^{-1}; λ_{max} (CH_3OH) 420 (log ε 3.75), 370 (4.0), 285 (4.16), 240 (sh, 4.40), 227 nm (sh, 4.42); NMR ($CDCl_3$) δ 8.28 (d, 1, *J* = 9.0 Hz, aromatic), 7.77–7.26 (m, 10, aromatic), 7.13 (s, 1, H_2), 4.4 (q, 2, *J* = 7.0 Hz, $\mathbf{CH_2}CH_3$), 1.4 (t, 3, *J* = 7.0 Hz, $CH_2\mathbf{CH_3}$); M^+· 315 (100). Anal. Calcd for $C_{21}H_{17}NO_2$: C, 79.98; H, 4.53; N, 4.44. Found: C, 79.59; H, 5.25; N, 4.37.

Reaction of 2 (R = Ph) with Fumaronitrile. The mesoionic compound (0.53 g, 2 mmol), fumaronitrile (0.16 g, 2 mmol), and toluene (30 mL) were refluxed for 24 h. Evaporation of the toluene in vacuo and trituration of the residue with hot ethanol gave a solid that crystallized from $CHCl_3$: EtOH as golden yellow needles of 3,4-dicyano-2-phenyl-1*H*-pyrido[1,2-*a*]quinolin-1-one (**12**): 28%; mp 304–305 °C; IR (KBr) 2210 (CN), 1685 cm^{-1} (CO); M^+· 321 (80). Anal. Calcd for $C_{21}H_{11}N_3O$: C, 78.49; H, 3.45; N, 13.08. Found: C, 78.20; H, 3.24; N, 12.93.

Registry No.—1 (R = H), 56919-56-3; 1 (R = Ph), 66102-80-5; 2 (R = Ph), 43091-21-0; **3**, 66102-81-6; **4** (R = H), 10002-29-6; **6**, 66102-82-7; **9** (R = H; R = COOEt), 52249-53-3; **9** (R = R^1 = $COOCH_3$), 20958-83-2; **12**, 66102-83-8; 2-mercaptoquinoline, 2637-37-8; bromoacetic acid, 79-08-3; 2-mercaptopyridine, 2637-34-5; bromoacetyl chloride, 22118-09-8; α-bromophenylacetyl chloride, 19078-72-9; α-bromophenylacetic acid, 4870-65-9; dimethyl acetylenedicarboxylate, 762-42-5; ethyl propiolate, 623-47-2; fumaronitrile, 764-42-1.

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Synthesis of α-Methoxyaliphatic Acids from Chloroform and Aliphatic Aldehydes with Sodium Hydride as Catalyst in Tetrahydrofuran

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The preparations of α-methoxyaliphatic acids, which we report here, have not been reported previously by any other method. A number of earlier articles have reported the condensation of chloroform (or bromoform) with aryl aldehydes to produce either aryl trihalomethyl-substituted methanols[1] or the products of the reaction of such alcohols[2] with base and/or solvent. In the latter cases, α-substituted arylacetic acids are often produced, where the α substituent has been methoxyl[3] (or alkoxyl,[4] in general), hydroxyl,[5] amino,[6] and even chloro.[7]

Past attempts to carry out similar reactions with aliphatic aldehydes replacing the aryl aldehydes have met with little success,[8] resulting usually in the formation of tars (from aldol condensations) rather than the alkyl (trichloromethyl)-methanols (aliphatic ketones[8] do, however, condense with chloroform, usually in 80% yields). Thus, at moderate temperatures (10–15 °C), most aliphatic aldehydes undergo the aldol condensation in the presence of strong base. To avoid this competing reaction, we have devised a procedure described below involving the addition of the aldehyde in chloroform to sodium hydride at 0–5 °C. The resulting alkyl (trichloromethyl)methanol containing solution, on addition of methanolic potassium hydroxide and heat, is converted to the product α-methoxyaliphatic acid, allowing a "one-batch" conversion.

$$RCHO + HCCl_3 + THF \xrightarrow[(2)\ NaOH/CH_3OH]{(1)\ NaH/THF} \underset{\displaystyle OCH_3}{\overset{\displaystyle RCHCO_2H}{|}}$$

There is evidence[9] for a general mechanism for these related haloform condensations, a mechanism involving an epoxide intermediate, which undergoes ring opening with solvent (or base) nucleophile to produce the various α-substituted acids after hydrolysis:

$$RCHO + CHCl_3\ (\text{or } CHBr_3) \xrightarrow[\text{catalyst}]{\text{base}} \underset{\displaystyle OH}{\overset{\displaystyle RCHCCl_3}{|}}$$

$$\xrightarrow{KOH} RCH\underset{O}{\overset{Cl}{-C}}\underset{Cl}{} \xrightarrow{XH} \underset{X}{\overset{RCHC(=O)Cl}{|}} \xrightarrow{H_2O} \underset{X}{\overset{RCHCO_2H}{|}}$$

In our chloroform condensation, the yields of the α-methoxyaliphatic acids have been generally good, varying from 51 to 63%, in most cases (with one 24% exception).

Other variations tried were a mixture of Me_2SO and THF (Me_2SO–THF 1:10) and 1,4-dioxane as solvent systems. The use of bromoform (replacing chloroform), a variety of reactant stoichiometries and orders of addition, potassium hydroxide in methanolysis (replacing sodium hydroxide), and a number of temperature conditions were tried. The reaction did not work if bromoform was substituted for chloroform. Also, we were not able to modify the methodology to produce the α-hydroxy- or α-aminoaliphatic acids. However, alkyl (trichloromethyl)methanols were isolated in good (80%) yields in two trials (using isobutyraldehyde and *n*-pentanal) and thus we feel certain that given the right conditions these other α-substituted aliphatic acids should be achievable.

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Experimental Section

To a 100-mL three-necked flask are added 250 mL of tetrahydrofuran (THF) and slightly more than ⅓ mol of sodium hydride (about 9 g). This mixture is cooled to between 0 and 5 °C in an ice–salt bath and kept under nitrogen gas throughout the reaction (much aldehyde oxidation occurs otherwise).

The aliphatic aldehyde (⅛ mol) and chloroform (¼ mol = 20.4 mL) is added to the flask dropwise over a period of 1–1.5 h after which the solution is stirred for an additional 3–3.5 h at the ice–salt bath temperature. (The reaction is exothermic and is likely to erupt from the flask if the temperature is allowed to rise above 20 °C.) Then 35 g of sodium hydroxide pellets dissolved in 150 mL of methanol are added to the flask dropwide with continued stirring over a period of 1 h. During the methanol addition the reaction is exothermic but the temperature is maintained below 40 °C with the ice bath. After completion of this addition, the reaction mixture is heated with a Glas-col heater and the temperature is kept in the range of 70–75 °C for a period of 2–3 h during methanolysis. The reaction mixture is allowed to stand overnight while cooling down to room temperature. Usually a yellow or pale-yellow solution containing a thick layer of white precipitate is obtained which is transferred to a beaker along with 200–250 mL of distilled water, warmed if necessary to dissolve all the inorganic products. The solution, which should be highly basic (pH 12), is cooled and extracted several times with ether to remove the neutral and basic materials. The solution is adjusted to pH 1, with hydrochloric acid. An oily layer appears on the solution surface, consisting of the α-methoxyaliphatic acid and trace impurities. This oil is removed by three 50-mL ether extractions. The ether extract is dried with sodium sulfate, refluxed with activated charcoal, and filtered and the ether is evaporated (the last traces under vacuum). The crude oils obtained suggest yields in the range of 69–80% of the theory. Vapor phase chromatograms run of these oils show impurities to average 5–8% of the crude acid giving yields before purification of 62–76% (with one exception, α-methoxyundecanoic acid, whose yield is 45%).

The purification of these oily acids is accomplished using a microdistillation system under reduced pressure. The final analytical product distillates varied in yield from 51 to 63% (24% for α-methoxyundecanoic acid).

Analytical and Spectroscopic Data of the α-Methoxyaliphatic Acids. General. Distillations were carried out using Bantam Ware apparatus. The infrared spectra were obtained on a Beckman IR-8. ^{1}H NMR spectra were obtained using a Joelco Model JNM-C-60HL and are reported in parts per million downfield from internal tetramethylsilane. The indicated yields are amounts obtained after careful distillation, one fraction of which was analytically pure.

2-Methoxyheptanoic acid: bp 246–250 °C; yield 54%; IR_{max} (neat) 3200–2500, 1700, 1420, 1190, 1120, 1095, 720 cm^{-1}; NMR ($CDCl_3$) δ 0.98 (3 H, triplet), 1.45 (8 H, complex), 3.44 (3 H, singlet), 3.69 (1 H, triplet), 13 (1 H, singlet). Anal. Calcd for $C_8H_{16}O_3$: C, 59.97; H, 10.06; OCH_3, 19.37. Found: C, 60.00; H, 10.14; OCH_3, 18.93.

2-Methoxyoctanoic acid: bp 49–52 °C (12 mmHg); yield 53%; IR_{max} (neat) 3200–2500, 1700, 1420, 1190, 1120, 1095, 720 cm^{-1}; NMR ($CDCl_3$) δ 0.98 (3 H, triplet), 1.40 (10 H, complex), 3.42 (3 H, singlet), 3.75 (1 H, triplet), 13.1 (1 H, singlet). Anal. Calcd for $C_9H_{18}O_3$: C, 62.04; H, 10.41; OCH_3, 17.81. Found: C, 61.97; H, 10.24; OCH_3, 18.12.

2-Methoxy-3,4-dimethylhexanoic acid: bp 246–250 °C; yield 56%; IR_{max} (neat) 3200–2500, 1700, 1420, 1360, 1195, 1095, 940 cm^{-1}; NMR ($CDCl_3$) δ 0.98 (9 H, complex), 1.8 (4 H, complex), 3.52 (3 H, singlet), 3.78 (1 H, complex), 13.45 (1 H, singlet). Anal. Calcd for $C_9H_{18}O_3$: C, 62.04; H, 10.41; OCH_3, 17.81. Found: C, 62.01; H, 10.34; OCH_3, 17.53.

2-Methoxy- 3-methylbutanoic acid: bp 197–201 °C; yield 59%; IR_{max} (neat) 3200–2500, 1700, 1420, 1375, 1160, 1190, 1095, 980–900 cm^{-1}; NMR ($CDCl_3$) δ 1 (6 H, quartet), 2.1 (1 H, septet), 3.56 (1 H, doublet), 3.48 (3 H, singlet). Anal. Calcd for $C_6H_{12}O_3$: C, 54.53; H, 9.15. Found: C, 54.58; H, 9.06.

2-Methoxpentanoic acid: bp 193–197 °C; yield 57%; IR_{max} (neat) 3200–2500, 1700, 1420, 1190, 1120, 1095, 720 cm^{-1}; NMR ($CDCl_3$) δ 0.97 (3 H, triplet), 1.65 (4 H, complex), 3.45 (3 H, singlet), 3.72 (1 H, triplet), 13.9 (1 H, singlet). Anal. Calcd for $C_6H_{12}O_3$: C, 54.53; H, 9.15; OCH_3, 23.48. Found: C, 54.38; H, 9.16; OCH_3, 23.53.

2-Methoxyhexanoic acid: bp 47–50 °C (13 mmHg); yield 53%; IR_{max} (neat) 3200–2500, 1700, 1420, 1190, 1120, 1095, 720 cm^{-1}; NMR (CCl_4) δ 0.98 (3 H, triplet), 1.42 (6 H, complex), 3.43 (3 H, singlet), 3.69 (1 H, triplet), 12.8 (1 H, singlet). Anal. Calcd for $C_7H_{14}O_3$: C, 57.51; H, 9.65; OCH_3, 21.22. Found: C, 57.37; H, 9.74; OCH_3, 20.69.

2-Methoxynonanoic acid: bp 260–264 °C; yield 54%; IR_{max} (neat) 3200–2500, 1700, 1420, 1195, 1110, 1095, 940, 720 cm^{-1}; NMR ($CDCl_3$) δ 0.98 (3 H, triplet), 1.43 (12 H, complex), 3.45 (3 H, singlet), 3.77 (1 H, triplet), 13.2 (1 H, singlet). Anal. Calcd for $C_{10}H_{20}O_3$: C, 63.80; H, 10.71; OCH_3, 16.48. Found: C, 63.83; H, 10.59; OCH_3, 16.62.

2-Methoxydecanoic acid: bp 278–281 °C; yield 51%; IR_{max} (neat) 3200–2500, 1705, 1420, 1095, 720 cm^{-1}; NMR (CCl_4) δ 0.98 (3 H, triplet), 1.42 (14 H, broad complex), 3.45 (3 H, singlet), 3.77 (1 H, triplet), 13.5 (1 H, singlet). Anal. Calcd for $C_{11}H_{22}O_3$: C, 65.31; H, 10.69. Found: C, 65.37; H, 10.96.

2-Methoxy-2-cyclohexylethanoic acid: bp 241–245 °C; yield 63%; IR_{max} (neat) 3200–2500, 1700, 1410 (doublet), 1110, 950–880 (broad) cm^{-1}. Anal. Calcd for $C_9H_{16}O_3$: C, 62.77; H, 9.36. Found: C, 62.79; H, 9.36.

Registry No.—2-Methoxyheptanoic acid, 64769-03-5; 2-methoxyoctanoic acid, 66018-23-3; 2-methoxy-3,4-dimethylhexanoic acid, 66018-24-4; 2-methoxy-3-methylbutanoic acid, 66018-25-5; 2-methoxypentanoic acid, 66018-26-6; 2-methoxyhexanoic acid, 66018-27-7; 2-methoxynonanoic acid, 66018-28-8; 2-methoxydecanoic acid, 66018-29-9; 2-methoxy-2-cyclohexylethanoic acid, 15540-18-8; hexanal, 66-25-1; heptanal, 111-71-7; 2,3-dimethylpentanal, 32749-94-3; 2-methylpropanal, 78-84-2; butanal, 123-72-8; pentanal, 110-62-3; octanal, 124-13-0; nonanal, 124-19-6; cyclohexanecarboxaldehyde, 2043-61-0; chloroform, 67-66-3; sodium hydride, 7646-69-7; tetrahydrofuran, 109-99-9.

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Revision of the Stereochemical Assignment of a Cyclobutane Derivative from Chalcone Photodimerization via X-ray Diffraction Analysis

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In a previous report[2] some of us described the stereochemistry of a chalcone photodimer as having β-truxinic structure **1**. This stereochemical assignment was made essentially on the basis of ^{1}H-NMR data and their comparison with data for a number of structurally related compounds. Subsequently, because the two internal rotation angles θ_1 and θ_2 of the benzoyl groups permit different conformational preferences, we wished to compare the conformation in the solid state with that derived from our data in solution. Furthermore, we wanted to determine if the cyclobutane ring was puckered out of the plane because of the four bulky substituents attached to it. In fact, few data exist in the literature[3,4] about the solid-state structure of cyclobutane derivatives in which no bonds of the four-membered ring are inserted in a fused structure or in which each carbon of the ring bears one substituent.

For these reasons, an x-ray structure determination was

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