IR spectrum (ν, cm $^{-1}$): 1130 and 1210 (CF_2, CF_3), 1500 and 1524 (C=C), 1562 (C=N). UV spectrum (λ_{max}, nm): 286 (EtOH). PMR spectrum (δ, ppm): 8.50-8.67 ($2H_o$), 7.37-7.57 ($2H_m$ + H_p). ^{19}F NMR spectrum (δ, ppm): 124.9 (CF_3–CF_2), 120.0 $(CF_2)_3$, 114.1 (CF_2–C), 81.6 (CF_3). Found: C 31.81; H 0.62; F 62.25; N 5.38%; mol. mass 789 (ebullioscopically in C_6F_6). Calculated for $C_{21}H_5F_{26}N_3$: C 31.77; H 0.63; F 62.30; N 5.30%; mol. mass 793.

Intermediate (II). The reaction was carried out at −35°C and the N-methylbenzamidine: mononitrile ratio was 1:1. After 3 h, the reaction solution was placed on a Silufol UV-254 plate and eluted with ether–heptane. Intermediate (II) (R_f 0.44) was extracted with ether. IR spectrum (ν, cm^{-1}): 1060, 1210, 1230 (CF_3, CF_2), 1510 (C=C), 1600 (C=N), 2810, 2880, and 2940 (CH_3), 3310 (NH), 1360 and 1410 (CH_3, def). Found: C 37.88; H 2.15; F 51.02; N 8.84%. Calculated for $C_{15}H_{10}F_{13}N_3$: C 37.58; H 2.08; F 51.57; N 8.77%.

CONCLUSIONS

Heteroaromatization was carried out under mild conditions at 20°C to obtain 2-phenyl-4,6-diperfluorohexyl-1,3,5-triazine from N-alkylbenzamidines with the nitrile of perfluorohexanecarboxylic acid.

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SYNTHESIS OF 5-ALKYLIDENE-2-PYRROLIDINONES

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In previous communications [1-3], we described the regioselective bromination of the methyl group of methyl alkyl ketones and studied several approaches for the use of bromomethyl ketones in organic synthesis.

In a continuation of these studies, we carried out the cyclocondensation of octylamine with ketoesters (IVa)-(IVc) obtained from bromoketones (IIa)-(IIc) through intermediate Meldrum's acid derivatives (IIIa)-(IIIc) according to our prevous procedures [1, 3, 4].

The cyclocondensation of ketoesters (IVa)-(IVc) with octylamine proceeded at 170-175°C with the separation of water and methanol and led to 5-alkylidene-2-pyrrolidinones (Va)-(Vc) in 30-74% yields.

The structure of (Va)-(Vc) were demonstrated by elemental analysis UV, IR, PMR, and ^{13}C NMR spectroscopy and mass spectrometry (see Experimental).

The exocyclic position of the double bond in (Va)-(Vc) was adopted in accord with their PMR spectral data.

The cyclocondensation of ketoesters (Va)-(IVc) with octylamine presumably proceeds through intermediate imines (VIa)-(VIc) or enamines (VIIa)-(VIIc) and their intramolecular cyclization. An alternative scheme involving the formation of (Va)-(Vc) from intermediate ketoamides (VIIIa)-(VIIIc) appears less likely since ketoamide (VIIIa), obtained in low

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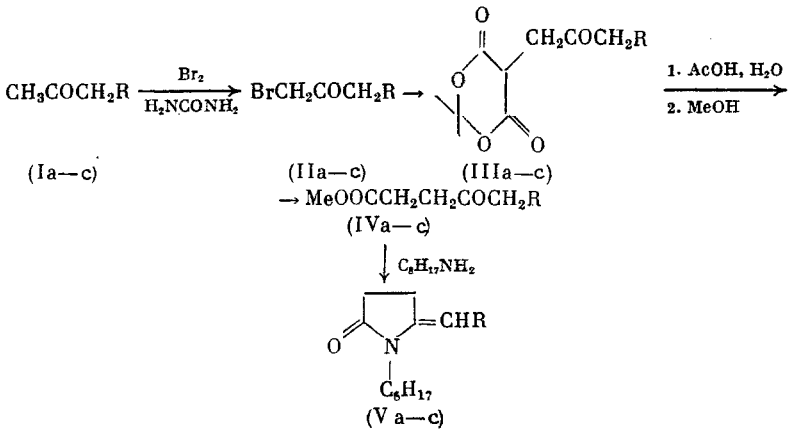
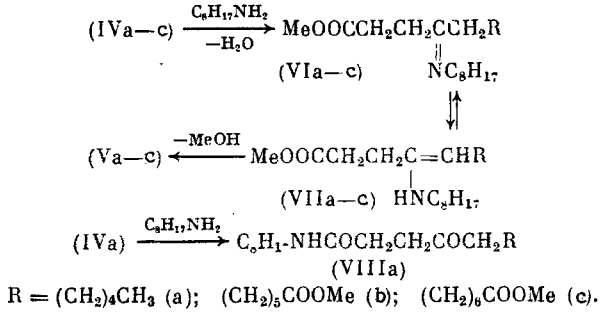


yield from ketoester (IVa) and octylamine at about 20°C, does not undergo thermal cyclization to give (Va) at 170-175°C.



The cyclocondensation of γ-ketoesters with primary amines was described without experimental details by Rinehart [5] and Sedavkina [6], who gave contradictory information on the position of the double bond in the reaction products.

2-Pyrroldinones may be considered simple azaanalogs of prostaglandins but their instability and insolubility in water do not permit biological testing.

EXPERIMENTAL

The PMR spectra were taken on a Tesla BS-467 spectrometer at 60 MHz and Bruker WM-250 spectrometer. The ^{13}C NMR spectra were taken on a Bruker AM-300 spectrometer. The IR spectra were taken neat and in KBr pellets on Perkin–Elmer 577 and Specord M-80 spectrometers. The UV spectra were taken in ethanol on a Specord VU-VIS spectrometer. The mass spectra were taken on a Varian MAT CH-6 mass spectrometer with direct sample inlet into the ion source. Thin-layer chromatography was carried out on Silufol UV-254 plates with development by UV light and iodine vapor.

Methyl Ester of 4-Oxodecanoic Acid (IVa). A sample of 2 ml concentrated sulfuric acid was added with stirring and cooling to a solution of 1.5 g (0.008 mole) 4-oxodecanoic acid obtained from 2-octanone according to our previous procedure [1, 3] in 20 ml methanol and maintained at about 20°C for four days. The solution was then heated at 85-87°C for 4 h. After cooling, the solution was partially evaporated, diluted with water, treated with excess sodium carbonate, and extracted with ethyl acetate (EA). The extract was dried over $MgSO_4$ and evaporated to give 1.15 g (72%) (IVa), bp 103-106°C (3 mm), n_D^{19} 1.4373 [7].

5-Hexylidene-1-octyl-2-pyrrolidinone (Va). A mixture of 4.59 g (0.0229 mole) ketoester (IVa) and 3.44 g (0.0266 mole) octylamine was heated for 2 h at 170-175°C. Distillation gave 4.72 g (74%) (Va), bp 153-156°C (2 mm), n_D^{20} 1.4826, Rf 0.53 (4:1 benzene–EA). UV spectrum: λ_{max} 233 nm. IR spectrum (ν, cm^{-1}): 1673 (C=C), 1721 (C=O). PMR spectrum in $CDCl_3$ (δ, ppm, J, Hz): 0.85 m ($2CH_3$), 1.24 m ($8CH_2$), 1.48 m (CH_2), 1.94 m (CH_2), 2.42 m (CH_2), 2.55 m (CH_2), 3.39 t (CH_2N, J = 7), 4.50 t (=CH, J = 7). ^{13}C NMR spectrum in $CDCl_3$ (δ, ppm): 175.15 (C=O), 139.06 and 128.23 (NC=C, E and Z isomers), 100.59 (NC=C, E and Z isomers), 39.83 (NCH_2), 31.74-13.98 [$(CH_2)_2$, $(CH_2)_4CH_3$, $(CH_2)_7CH_3$]. Mass spectrum, m/z 279 M^+, 222 $[M-C_4H_9]^+$.

An analytically pure sample of (Va) was obtained after chromatography on an alumina column with grade II activity using benzene as the eluent. Found: C 77.27; H 11.54; N 5.44%. Calculated for $C_{18}H_{33}NO$: C 77.36; H 11.90; N 5.01%.

Methyl Ester of 8-Oxononanoic Acid (Ib). A sample of 15 g (0.073) of the acid chloride of the monomethyl ester of octanedioic acid was added gradually with stirring and ice cooling to a solution of 10.5 g (0.073 mole) Meldrum's acid in 8 ml dry pyridine and 16 ml dry CH_2Cl_2 and maintained for 1 h at about 0°C and 1 h at about 20°C. The reaction mixture was poured into water and an excess of a solution prepared by adding one part concentrated hydrochloric acid and one part water was added. The product was extracted with ethyl acetate and dried over Na_2SO_4. The solvent was evaporated in vacuum. Then, 75 ml acetic acid and 10 ml water was added to the residue and heated at reflux for 40 min. After evaporation, 120 ml methanol and 12 ml Me_3SiCl was added to the reaction mixture, maintained for 24 h at room temperature, and then heated at reflux for 3 h. The solvent was partially evaporated. The residue was diluted with water, extracted with ethyl acetate, and dried over Na_2SO_4. Distillation gave 7.8 g (57%) (Ib), bp 115-116°C (3 mm), n_D^{23} 1.4357 [9]. PMR spectrum in CCl_4 (δ, ppm): 1.33 m [$(CH_2)_4$], 1.97 s (CH_3CO), 2.18 m ($2CH_2$), 3.54 s (OCH_3).

A sample of 7.2 g (0.0348 mole) acid chloride of the monomethyl ester of octanedioic acid was added gradually with stirring and water cooling to 5 g (0.0346 mole) Meldrum's acid in 10 ml dry pyridine and maintained for 1 h at 0°C and 1.5 h at 20°C. The reaction mixture was poured into water and treated with an excess of a solution prepared by adding one part concentrated hydrochloric acid and one part water. The product was extracted with ethyl acetate and dried over $MgSO_4$. The solvent was evaporated in vacuum. Then, 20 ml acetic acid and 5 ml water were added to the residue and heated for 50 min at 80-90°C. The mixture was evaporated and the residue was diluted with water, treated with excess Na_2CO_3, extracted with ethyl acetate, and dried over $MgSO_4$. Evaporation of the solvent and distillation of the residue gave 3.5 g (54%) (Ib), bp 107-109°C (2 mm), n_D^{21} 1.4378.

Dimethyl Ester of 4-Oxoundecandioic Acid (IVb). A sample of 1.1 g (0.0183 mole) urea and 0.86 ml (0.0168 mole) Br_2 were addded with stirring to a solution of 3.15 g (0.0169 mole) (Ib) in 14.5 ml methanol and maintained for 24 h at about 20°C. The mixture was diluted with water, maintained for 1 h, extracted with CH_2Cl_2, and dried over sodium sulfate. Evaporation of the solvent gave 4.2 g (IIb), which was used without further purification.

A sample of 3.8 g (0.0143 mole) bromide (IIb) was added to a solution of 2.1 g (0.0145 mole) Meldrum's acid and 2.8 g (0.0205 mole) $NaOAc \cdot 3H_2O$ in 13 ml DMF. The mixture was maintained for 72 h at 20°C, diluted with water, and treated with excess potassium carbonate. The impurities were extracted with ether. The basic solution was acidified with a solution composed of one part concentrated hydrochloric acid and one part water and again extracted with ether. The extract was dried over magnesium sulfate and evaporated in vacuum. Then, 20 ml acetic acid and 5 ml water were added to the residue (IIIb) and heated for 2 h at 120°C. The solvent was evaported and 20 ml methanol and 2 ml Me_3SiCl were added to the residue, maintained for 72 h at about 20°C, and heated at reflux for 2.5 h. The mixture was diluted with water, treated with excess sodium carbonate, extracted with ethyl acetate, and dried over magnesium sulfate to give 1.77 g (45%) (IVb), Rf 0.51 (4:1 benzene–ethyl acetate) [10]. PMR spectrum in $CDCl_3$ (δ, ppm): 1.32 m [$(CH_2)_4$], 1.95-2.75 m ($4CH_2CO$), 3.55 s ($2CH_3O$).

5-(6-Methoxycarbonylhexyliden)-1-octyl-2-pyrrolidinone (Vb). A mixture of 0.5 g (0.0019 mole) (IVb) and 0.27 g (0.0021 mole) octylamine was heated for 2 h at 170-175°C and evaporated in vacuum (the bath temperature was about 75°C). The residue was subjected to chromatography on alumina using 9:1 benzene–ethyl acetate as the eluent to give 0.2 g (30.6%) (Vb), Rf (5:1.5 benzene–ethyl acetate). UV spectrum: λ_{max} 233 nm. IR spectrum (ν, cm^{-1}): 1672 (C=C), 1721 (NC=O), 1741 (C=O). PMR spectrum in $CDCl_3$ (δ, ppm, J, Hz): 0.85 t (CH_3, J = 6.5), 1.25 m ($7CH_2$), 1.49 m (CH_2), 1.53 m (CH_2), 2.00 m (=$CHCH_2$), 2.30 t (CH_2CO, J = 7), 2.45 m (CH_2), 2.58 m (CH_2), 3.40 t (CH_2N, J = 7), 3.65 s (CH_3O), 4.59 t (=CH, J = 7). ^{13}C NMR spectrum in $CDCl_3$ (δ, ppm): 175.31 (C=O), 174.12 (C=O), 139.34 and 128.34 (NC=C, E and Z isomers), 100.23 (NC=C, E and Z isomers), 51.47 (OCH_3), 39.88 (NCH_2), 37.01-14.09 [$(CH_2)_2$, $CH_2)_4$, $(CH_2)_7CH_3$]. Mass spectrum, m/z 337 M^+, 222 (M – $C_6H_{11}O_2$]$^+$. Found: C 71.03; H 10.34; N 3.92%. Calculted for $C_{20}H_{35}NO_3$: C 71.17; H 10.45; N 4.15%.

Dimethyl ester of 4-oxododecanedioic acid (IVc) was obtained from (Ic) [11] according to our previous procedure [1, 4].

5-(6-Methoxycarbonylheptyliden)-1-octyl-2-pyrrolidinone (Vc). A mixture of 0.72 g (0.0026 mole) (IVc) and 0.37 g (0.0028 mole) octylamine was heated for 2 h at 170-175°C and evaporated in vacuum (the bath temperature was about 75°C). The residue was subjected to chromatography on an alumina column with 9:1 benzene–ethyl acetate as the eluent to give 0.43 g (46%) (Vc), Rf 0.48 (5:1 benzene–ethyl acetate). UV spectrum: λ_{max} 232 nm. IR spectrum (ν, cm ^{1}): 1672 (C=C), 1718 (NC=O), 1740 (C=O). PMR spectrum in $CDCl_3$ (δ, ppm, J, Hz): 0.79 t (CH_3, J = 7), 1.20 m ($8CH_2$), 1.43 m (CH_2), 1.55 m (CH_2), 1.93 m (=CHC$\underline{H}_2$), 2.23 t (CH_2CO, J = 7), 2.38 m (CH_2), 2.41 m (CH_2), 3.34 t (CH_2N, J = 7), 3.58 s (CH_3O), 4.55 t (=CH, J = 7). ^{13}C NMR spectrum in $CDCl_3$ (δ, ppm): 175.28 (C=O), 174.13 (C=O), 139.29 and 128.30 (NC=C, E and Z isomers), 100.45 and 100.21 (NC=C, E and Z isomers), 51.35 (OCH_3), 39.88 (NCH_2), 37.03-14.01 [$(CH_2)_5$, $(CH_2)_2$, $(CH_2)_7CH_3$]. Found: C 68.46; H 10.64; N 4.15%. Calculated for $C_{21}H_{37}NO_3 \cdot H_2O$: C 68.25; H 10.63; N 3.79%.

N-Octylamide of 4-Oxodecanoic Acid (VIIIa). A mixture of 0.47 g (0.0023 mole) (IVa) and 0.35 g (0.0027 mole) octylamine was maintained at room temperature for 48 h. The crystalline precipitate was filtered off and washed with cold ether to give 0.1 g (14.6%) (VIIIa), mp 83.84°C, Rf 0.36 (4:1 benzene–ethyl acetate). IR spectrum (ν, cm^{-1}): 1570 (amide II), 1645 (amide I), 1710 (C=O). PMR spectrum, in $CDCl_3$ (δ, ppm, J, Hz): 0.85 m ($2CH_3$), 1.25 br. s ($8CH_2$), 1.36-1.60 m ($2CH_2$), 2.40 m ($2CH_2$), 2.74 t (CH_2, J = 6), 3.18 m ($C\underline{H}_2NH$), 5.89 br. s (NH). Found: C 72.88; H 11.73; N 4.78%. Calculated for $C_{18}H_{35}NO_2$: C 72.67; H 11.86; N 4.71%.

CONCLUSIONS

Heating γ-ketoesters with octylamine gives 5-alkylidene-2-pyrrolidinones.

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