must involve hydration of the nitrone function to give XI followed by a conventional α-hydroxy–carbonyl rearrangement (XI, see arrows) and subsequent dehydration of the intermediate α-carbinolhydroxylamine.

Experimental Section

General.—All melting points were taken on a Kofler block and are uncorrected. Infrared spectra were measured on a Perkin-Elmer 137 Infracord spectrometer and ultraviolet spectra on a Cary Model II spectrometer. Nmr spectra were taken in $CDCl_3$ on a Varian A-60 spectrometer. Microanalyses were done by Dr. A. Bernhardt, Max Planck Institute, Mülheim (Ruhr), Germany.

Acetylation of 2,4,4-Trimethyl-1-pyrroline 1-Oxide (I, R = Me).—The nitrone (I, R = Me,[1] 5.0 g) in carbon tetrachloride (120 ml) was treated with ice-cold acetic anhydride (18.8 ml) added dropwise with stirring at −20° and held at this temperature for 5 hr. The solution was then left at room temperature for 16 hr, poured into ice–water, and extracted with methylene dichloride. After it was washed with aqueous sodium hydrogen carbonate solution and with water the solvent was removed *in vacuo* to furnish a viscous red oil. This was chromatographed in methylene dichloride over Florisil to give a pale yellow oil which crystallized on trituration with ether–hexane. Recrystallization from hexane afforded acetate III (3.0 g): mp 49°; ν_{max}^{Nujol} 1745, 1675, and 1640 cm^{-1}; τ 8.95 (3 H), 8.89 (3 H), 7.89 (3 H), 7.82 (3 H), 6.61 and 6.46 (2 H, J = 10 cps), 5.21 (1 H), 4.80 (1 H), and 4.02 1 (H).

Anal. Calcd for $C_{11}H_{17}NO_3$: C, 62.54; H, 8.11; N, 6.63. Found: C, 62.74; H, 8.32; N, 6.61.

Acetate III (800 mg) in benzene (150 ml) was hydrogenated over 5% palladized charcoal (800 mg) for 5.5 hr (1-mol uptake). The resultant suspension was filtered through "Hyflo Supercel" and the benzene removed *in vacuo*. The resultant oily product was chromatographed in benzene over Florisil to give a trace of starting material and then dihydroacetate IV as an oil: $\nu_{max}^{thin\ film}$ 1745 and 1640 cm^{-1}; τ 8.96 (6 H), 8.83 and 8.71 (3 H, J = 7 cps), 7.95 (3 H), 7.87 (3 H), 6.69 (2 H), 5.69 (1 H), and 4.97 (1 H).

Acid-Catalyzed Hydrolysis of Acetate III.—Acetate III (1.33 g) in glacial acetic acid (20 ml) and water (2 ml) was treated with concentrated hydrochloric acid (3 drops) at 0° for 45 min. The solution was poured into water and extracted with methylene dichloride. The organic phase was washed with aqueous sodium hydrogen carbonate and with water and the solvent removed *in vacuo* to furnish ketoamide V (730 mg). The aqueous phases were combined; excess sodium hydrogen carbonate and sodium borate were added; the mixture was extracted with methylene dichloride to furnish additional ketoamide V (202 mg). Ketoamide V was an oil: $\nu_{max}^{thin\ layer}$ 3400, 1750, 1725, and 1665 cm^{-1}, τ 8.99 (6 H), 8.01 (3 H), 7.80 (6 H), 6.80 (2 H).

Ketoamide V was characterized as the 2,4-dinitrophenylhydrazone. Recrystallized from ethanol, this had mp 113–115°; ν_{max}^{Nujol} 3340, 3150, 1740, 1640, 1625, 1590, and 1515 cm^{-1}.

Anal. Calcd for $C_{17}H_{23}N_5O_7$: C, 49.87; H, 5.66; N, 17.11; mol wt, 409.4. Found: C, 49.88; H, 5.52; N, 17.06; mol wt (Rast), 381.

Treatment of acetate III with acidified 2,4-dinitrophenylhydrazine in the usual way gave the same 2,4-dinitrophenylhydrazone.

Selenium Dioxide Oxidation of 2,4,4-Trimethyl-1-pyrroline 1-Oxide (I, R = Me).—The pyrroline 1-oxide (1.0 g) in ether (30 ml) was treated with selenium dioxide (970 mg) at room temperature for 20 min. The suspended selenium was removed by filtration through a small pad of Florisil and the solvent removed *in vacuo*. Chromatography in methylene dichloride over Florisil gave, as minor product, rearranged nitrone X (identical in all respects with a specimen prepared by the standard method[5]). Further elution afforded as the major product (715 mg) the aldehyde (I, R = CHO, 715 mg), which was an oil: $\nu_{max}^{thin\ film}$ 1665 and 1545 cm^{-1}; τ 8.70 (6 H), 7.30 (2 H), 6.09 (2 H), and −0.07 (1 H). The aldehyde readily afforded a dimedone derivative in aqueous methanol at room temperature. Recrystallized from aqueous methanol this had mp 175–180°.

Anal. Calcd for $C_{23}H_{33}O_5N$: C, 68.46; H, 8.24; N, 3.47. Found: C, 68.39; H, 8.37; N, 3.34.

When aldehyde I (R = CHO) in methanol was treated with acidic 2,4-dinitrophenylhydrazine solution in the usual manner it afforded the 2,4-dinitrophenylhydrazone of keto nitrone X.

Oxidation of Aldehyde I (R = CHO) with Silver Oxide (with Dr. D. R. Brittain).—Aldehyde I (R = CHO) [prepared from nitrone I (R = Me, 1.7 g)], suspended in water (20 ml), was treated with stirring with silver oxide [prepared from silver nitrate (4.64 g) and sodium hydroxide (2.18 g)] at room temperature for 2 hr. The mixture was extracted with chloroform. The pH of the aqueous phase was then adjusted to 1.0 and extraction with chloroform was repeated. This second chloroform extract was evaporated *in vacuo* and the residue crystallized from ether–*n*-hexane to give carboxylic acid I (R = CO_2H, 700 mg): mp 80–92°; λ_{max}^{MeOH} 266 mμ (ε 6700); ν_{max}^{KBr} 1520 cm^{-1}

Anal. Calcd for $C_7H_{11}NO_3$: C, 53.49; H, 7.05; N, 8.91. Found: C, 53.50; H, 7.20; N, 9.64.

Registry No.—I (R = Me), 6931-11-9; I (R = CHO) dimedone derivative, 19689-70-4; I (R = CO_2H), 19713-63-4; III, 19689-71-5; IV, 19689-72-6; V, 19689-73-7; V (2,4-dinitrophenylhydrazone), 19689-74-8.

2,2-Dichlorocyclopropyl Acetates as Intermediates for the Preparation of Pyrazoles and Pyrimidines

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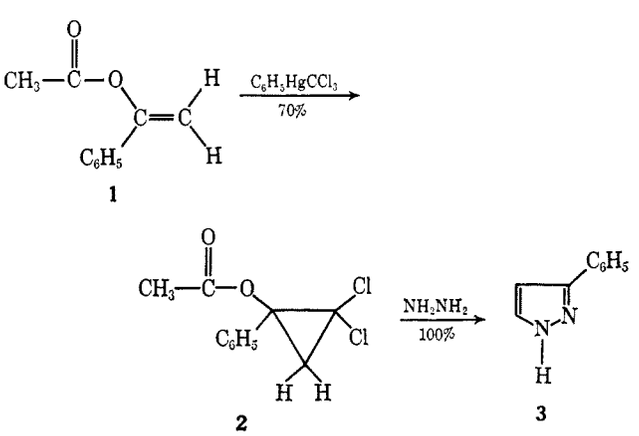
The reaction of *gem*-dihalocyclopropyl acetates with hydrazine and substituted hydrazines provides a new synthetic route to pyrazoles.[3] In order to define further the scope of this synthesis, reactions of compounds of type 2 with a variety of nucleophiles have been examined; the results of this study constitute the subject of this report.

α-Acetoxystyrene (1) was treated with excess phenyl(trichloromethyl)mercury and 2,2-dichloro-1-phenylcyclopropyl acetate (2) was obtained in 70% yield. The cyclopropyl acetate (2) was shown to undergo facile ring opening with 4.5 equiv of 95% hydrazine in hot ethanol, and gave an essentially quantitative yield of 3-phenylpyrazole (3).

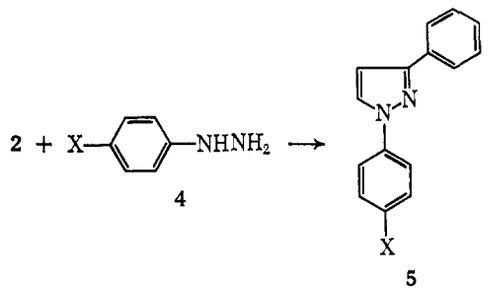


(1) Supported by the National Science Foundation Grant GP-6169X.

(2) Taken in part from the Ph.D. Thesis of J. F. Dooley, University of Minnesota, 1967.

(3) (a) W. E. Parham and J. F. Dooley, *J. Amer. Chem. Soc.*, **89**, 985 (1967); (b) W. E. Parham and J. F. Dooley, *J. Org. Chem.*, **33**, 1476 (1968).

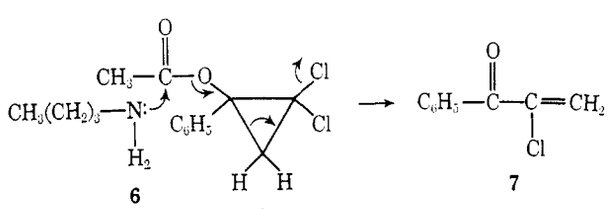
Reaction of 2 with excess phenylhydrazine in hot ethanol for 13.5 hr gave 1,3-diphenylpyrazole (**5a**) in 35% yield. However, attempts to extend this reaction to include *p*-bromo- or *p*-nitrophenylhydrazine were unsuccessful; no reaction occurred under conditions essentially identical with those used with phenylhydrazine.



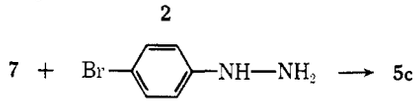
4 5

a, X = H
b, X = NO_2
c, X = Br

The inability of **4b** or **4c** to react with ester 2 suggested that the substituent had lowered the nucleophilicity of the substituted phenylhydrazine to the point that ester aminolysis was unable to occur under the conditions employed. In order to test this assumption, the reaction of 2 with 1.5 equiv of *p*-bromophenylhydrazine was carried out as before, but in the presence of excess *n*-butylamine. *n*-Butylamine is known to react[4,5] readily with esters, and it was anticipated that aminolysis of 2 by the more nucleophilic amine would give the α,β-unsaturated chloro ketone (**7**), which would in turn react irreversibly with the weakly nucleophilic hydrazine in the system to give the pyrazole. Under these conditions the pure pyrazole **5c** was obtained in 27% yield; somewhat improved yields of **5c** were obtained (38%) when only a slight excess of *n*-butylamine was employed. In this case potassium acetate was used to neutralize the hydrogen chloride formed in the reaction.

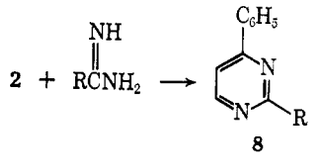


6 2 7



4c

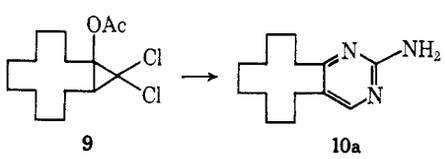
Cyclopropane 2 did not react with excess urea or thiourea in hot ethanol;[6] however, condensation of 2 with an excess of the more basic guanidine gave 2-amino-4-phenylpyrimidine (**8a**) in 63% yield. The reaction of cyclopropane 2 with benzamidine afforded



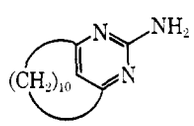
8

a, R = NH_2
b, R = C_6H_5

2,4-diphenylpyrimidine (**8b**), isolated in 64% yield. Attempts to extend this pyrimidine synthesis to methacyclophane **10b** were unsuccessful. Reaction of **9** with excess guanidine gave a viscous mixture which was purified by chromatography. 2-Amino-4,5-cyclododecapyrimidine (**10a**) was isolated in 12% yield as the only identifiable product. Reaction of **9** with hydrazine under similar conditions is known to give the corresponding 1,3-bridged pyrazole in >49% yield together with some of the 3,4-bridged pyrazole, and the duality of mechanism leading to these products has been discussed.[3] The structure of **10a** was established by its independent synthesis (see Experimental Section).

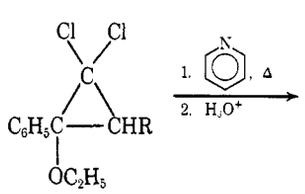


9 10a

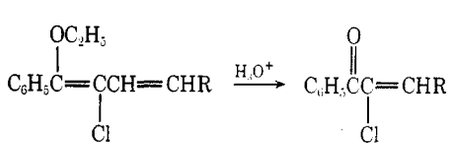


10b

α-Chloro ketones of type **7**, which are intermediates[3] in the synthesis of heterocycles from dichlocyclopropyl acetates, are also readily available from 2,2-dihalocyclopropyl ethers.[7] The preparation of chloro ketones **13a** and **13b**, and the conversion of **13a** into 3-phenyl-5-



11a, R = CH_3
b, R = C_4H_9



12a, R = H
b, R = C_3H_7

13a, R = CH_3
b, R = C_4H_9

methylpyrazole (74% yield) are described in the Experimental Section. Attempts to dehydrohalogenate **12b** to the corresponding triene with potassium *t*-butoxide, by a process analogous to that described for the prepara-

(4) W. H. Watanabe and L. R. De Donso, *J. Amer. Chem. Soc.*, **78**, 4542 (1956).

(5) P. A. Smith, "The Chemistry of Open-Chain Organic Nitrogen Compounds," Vol. I, W. A. Benjamin, Inc., New York, N. Y., 1965, p 29.

(6) These reagents are known to form pyrimidines with a variety of unsaturated carbonyl compounds or their analogs; *cf* D. J. Brown, "The Pyrimidines," John Wiley & Sons, Inc., New York, N. Y., 1962, Chapters II and III; C. H. Covallito, C. M. Matine, and F. C. Nachod, *J. Amer. Chem. Soc.*, **73**, 2544 (1951).

(7) W. E. Parham, R. W. Soeder, J. R. Throckmorton, K. Kuncl, and R. M. Dodson, *J. Amer. Chem. Soc.*, **87**, 321 (1965); W. E. Parham and R. J. Sperley, *J. Org. Chem.*, **32**, 926 (1967); L. Skattebøl, *ibid.*, **31**, 1454 (1966).

tion of ethoxy cyclohexatriene,[7] led to an unstable product which was not characterized.

Experimental Section

2,2-Dichloro-1-phenylcyclopropyl Acetate (2).—A solution of α-acetoxystyrene (**1**, 16.2 g, 0.10 mol) and phenyl(trichloromethyl)mercury[8] (51.5 g, 0.13 mol) in benzene was heated for 52 hr. The mixture was processed in the usual way,[8] and the product was distilled to give 17.1 g (70%) of **2**: bp 93° (0.01 mm); $n^{25}D$ 1.5310; ir 1760 cm^{-1} (C=O); nmr (CCl_4) τ 8.10 (s, 3, $OCOCH_3$), 7.90 (q, 2, J = 9 Hz, CH_2), and 2.70 (m, 5, C_6H_5). The acetate was crystallized from petroleum ether (bp 60–68°) and melted at 45–46.5°.

Anal. Calcd for $C_{11}H_{10}Cl_2O_2$: C, 53.90; H, 4.12; Cl, 28.93: Found: 53.55; H. 4.02; Cl, 28.70.

1. **Reaction of 2 with Hydrazine.**—A solution of hydrazine (95%, 1.52 g, 0.045 mol) in ethanol (5 ml) was added dropwise with cooling to a solution of 2,2-dichloro-1-phenylcyclopropyl acetate (**2**, 2.46 g, 0.010 mol) in ethanol (10 ml) and the resulting mixture was heated at the reflux temperature for 12 hr. A solution of sodium hydroxide (1.40 g, 0.040 mol) in water (10 ml) was added and the resulting mixture was heated at the reflux temperature for 1 additional hr. The solution was poured into water (50 ml) and extracted with three 30-ml portions of ether. The combined ether extracts were dried ($MgSO_4$) and concentrated on a rotary evaporator to give a yellow oil (1.55 g, $n^{25}D$ 1.6075). The oil was triturated with carbon tetrachloride (5 ml) and stored in the cold overnight. Filtration of the mixture gave 1.43 g (100%) of 3-phenylprazole (**3**): mp and mmp 77–78° (lit.[9] mp 78°); nmr (CCl_4) τ 3.69 (d, 1, J = 2.2 Hz, CH—CN), 2.70 (d, 1, J = 2.2 Hz, C=CHN), 2.43–2.99 (m, 5, C_6H_5), and −3.17 (1, NH).

2. **With Phenylhydrazine.**—The oil obtained subsequent to heating (13 hr at reflux) a solution of **2** (5.8 g, 0.024 mol), phenyl hydrazine (9.8 g, 0.10 mol), and 30 ml of absolute ethanol was chromatographed over silica gel (60 g); elution with petroleum ether (bp 60–68°) afforded the crude product. Crystallization of this material from absolute ethanol afforded 1.9 g (35%) of the pale yellow, crystalline 1,3-diphenylpyrazole (**5a**): mp 85.5–87° (lit.[10] mp 84–85°); nmr (CCl_4) τ 6.51 (d, 1, J = 2 Hz (CH=CHN), 2.08–3.15 (m, 11, C_6H_5 and CH=CHN).

3. **With *p*-Nitrophenylhydrazine.**—The reaction of *p*-nitrophenylhydrazine (2.82 g, 0.0184 mol) with **2** (1.00 g, 0.0041 mol) in ethanol (70 ml) was carried out as described in 1. After the solution had been heated at the reflux temperature for 16 hr, a reference compound (*m*-chlorobenzoic acid, 1.00 g) was added, and the homogeneous solution was subjected to glpc (20% silicone oil DC 710 on Chromosorb W, 150°, He, 50 ml/min). The presence of 1.00 g of starting ester (**2**) was demonstrated.

4. **With *p*-Bromophenylhydrazine.**—The results were essentially identical with those described with *p*-nitrophenylhydrazine.

5a. **With *p*-Bromophenylhydrazine and *n*-Butylamine.**—A solution of **2** (5.00 g, 0.021 mol), *p*-bromophenylhydrazine (5.27 g, 0.027 mol), and *n*-butylamine (6.14 g, 0.084 mol) was heated at the reflux temperature for 15 hr. A solution of sodium hydroxide (3.68 g, 0.092 mol) in water (50 ml) was added and the mixture was heated at the reflux temperature for an additional 0.5 hr. The cherry red reaction mixture was poured into water (100 ml) and extracted with three 100-ml portions of ether. The combined ether extracts were dried ($MgSO_4$) and concentrated on a rotary evaporator to give 10.0 g of a red oil. Crystallization of the oil from ethanol afforded 1.88 g (30%) of the crude 1-(*p*-bromophenyl)-3-phenylpyrazole, mp 129–132°. Recrystallization of this material afforded 1.72 g (27%) of pure **5c**: mp and mmp 139–140° (lit.[11] mp 137–138°); nmr ($CDCl_3$) τ 3.31 (d, 1, J = 2.5 Hz, CH=CHN), 2.21 (d, 1, J = 2.5 Hz, CH=CHN), 2.47 (m, 5, C_6H_5), and 2.38 (m, 4, BrC_6H_4).

5b. **With *p*-Bromophenylhydrazine and *n*-Butylamine.**—A solution of potassium acetate (1.5 g, 0.015 mol), *p*-bromophenylhydrazine (1.25 g, 0.0056 mol), and **2** (1.0 g, 0.0041 mol) in ethanol (15 ml) was heated at the reflux temperature for 50 min. To the solution was added dropwise a solution of *n*-butylamine (0.35 g, 0.0049 mol) and ethanol (4 ml) and the resulting solution was heated at the reflux temperature for 16 hr. The mixture was processed essentially as described above and gave 423 mg (35%) of the pale yellow, crystalline pyrazole, mp and mmp 139–140°. Chromatography of the residue on silica gel using benzene as the eluent afforded an additional 35 mg (3%) of **5c**, mp 139–140°.

6. **Reaction of 2 with Guanidine.**—A solution of sodium hydroxide (3.68 g, 0.092 mol) in water (10 ml) was added to a solution of guanidine hydrochloride (8.78 g, 0.092 mol) in water (10 ml). One drop of phenophthalein solution was added and the mixture stirred until the red color disappeared (*ca.* 10 min). Ethanol (70 ml) and a solution of **2** (5.00 g, 0.021 mol) in ethanol (10 ml) were added. The solution was heated at the reflux temperature for 2 hr, a solution of sodium hydroxide (3.68 g, 0.092 mol) in water (50 ml) was added, and the reaction mixture was heated at the reflux temperature for 0.5 hr. The mixture was cooled, poured into water (200 ml), and extracted with five 50-ml portions of ether. The combined ether extracts were washed once with a saturated sodium chloride solution (100 ml), dried ($MgSO_4$), and the solution was concentrated on a rotary evaporator to give 2.25 g (63%) of the yellow, crystalline 2-amino-4-phenylpyrimidine (**8a**), mp 164–165° (lit.[12] mp 165°, 164°). Vacuum sublimation of the product afforded the white, crystalline product: mp and mmp 165–166.5°; nmr ($DCCl_3$) τ 4.69 (2, NH_2), 0.03 (d, 1, J = 5.3 Hz, NCH=), 2.68 (d, 1, J = 5.3 Hz, HC=CHN), and 2.31 (m, 5, C_6H_5).

7. **Reaction of 2 with Benzamidine.**—To a solution of sodium ethoxide prepared from 0.480 g (0.0208 g-atom) of sodium and absolute ethanol (25 ml) was added 4.74 g (0.027 mol) of benzamidine hydrochloride hydrate. The solution was heated at the reflux temperature for 0.5 hr, cooled, and the excess benzamidine hydrochloride was removed by filtration. To the filtrate was added 1.10 g (0.0045 mol) of 2,2-dichloro-1-phenylcyclopropyl acetate in absolute ethanol (10 ml). The resulting solution was heated at the reflux temperature for 44 hr, poured into water (100 ml), and extracted with two 100-ml portions of ether. The combined ether extracts were dried (calcium chloride), filtered, and the solvent removed *in vacuo*. Crystallization of the residue from absolute ethanol afforded 0.693 g (64%) of the crude 2,4-diphenylpyrimidine, mp 68–71.5°. Recrystallization of this material afforded 0.470 g (43.5%) of 2,4-diphenylpyrimidine (**8b**), mp 71–73° (lit.[13] mp 71–72°).

2-Amino-4,5-cyclododecapyrimidine (10).—Chromatography of the product obtained by reaction of **9** with guanidine on neutral alumina (see section 6) gave 2-amino-4,5-cyclododecapyrimidine (**11**, 320 mg, 12% yield) as a yellow oil. Crystallization of this product from petroleum ether gave 312 mg of **11**: mp and mmp 198–200°; nmr (CCl_4) τ 8.59 (m, 16, CH_2), 7.40 (m, 4, CH_2C=C) 2.68 (s, 1, C=CH), 1.95 (2, NH_2); ir (Nujol) 3280 and 3110 (NH), 1660 cm^{-1} (C=N).

Anal. Calcd for $C_{14}H_{23}N_3$: C, 72.04; H, 9.95. Found: C, 72.28; H, 10.05.

2-Amino-4,5-cyclododecapyrimidine (10a) from 2-Hydroxymethylenecyclododecanone (12).—To a solution of 2-hydroxymethylenecyclododecanone[14] (**12**, 11.6 g, 0.055 mol) was added dropwise to a guanidine solution [0.01 mol in water (20 ml)] prepared as described above. After the addition was completed the solution was heated at the reflux temperature for 15 hr, cooled, and extracted with three 100-ml portions of ether. The combined ether extracts were dried ($MgSO_4$) and the solvent was removed *in vacuo*. Crystallization of the residue from chloroform–petroleum ether (bp 60–68°) afforded 0.60 g (5%) of the crystalline product **11**, mp 200°.

2,2-Dichloro-1-ethoxy-3-methyl-2-phenylcyclopropane (11a).—The reaction of 1-ethoxy-1-phenyl-1-propene (50 g, 0.308 mol) with sodium methoxide (21.6 g, 0.40 mol) and ethyl trichloroacetate (66.2 g, 0.346 mol) was carried out for 6 hr at 0°. The mixture was processed in the usual way,[7,15] and the residue was distilled, taking care to keep the temperature of the distillation flask below 100°, to give 39.2 g (69%) of **11a**: bp 62–67° (0.01–0.03 mm); $n^{25}D$ 1.5265; nmr (CCl_4) τ 2.67 (s, 5, C_6H_5),

(8) H. Hagenmeyer and D. Hull, *Ind. Eng. Chem.*, **41**, 2920 (1949).
(9) L. Knorr, *Ber.*, **28**, 696 (1895).
(10) K. V. Auwers and H. Mauss, *Ann.*, **452**, 182 (1927).
(11) H. L. Davies, *J. Amer. Chem. Soc.*, **68**, 1677 (1941).
(12) E. Bernary, *Ber.*, **63**, 2601 (1930); K. Bowden and E. Jones, *J. Chem. Soc.*, 953 (1946).
(13) V. T. Klimko, V. A. Mikholev and A. P. Skoldinov, *Zh. Obhch. Khim.*, **30**, 1258 (1960); *Chem. Abstr.*, **55**, 551a (1961).
(14) L. I. Zakharkin and U. V. Dorneva, *Izv. Adad. Nauk SSSR, Ser. Khim.*, **12**, 2206 (1964).
(15) W. E. Parham, R. W. Sooder, and R. M. Dodson, *J. Amer. Chem. Soc.*, **84**, 1755 (1962).

6.66 (m, 2, OCH_2CH_3), 8.10 (q, 1, J = 6 Hz, $CHCH_3$), 8.62 (d, 3, J = 6 Hz, $CHCH_3$), and 9.01 (t, 3, J = 7.0 Hz, OCH_2CH_3).

Anal. Calcd for $C_{12}H_{14}Cl_2O$: C, 58.79; H, 5.76. Found: C, 58.79; H, 5.40.

α-Chlorocrotonophenone (13a).—A mixture of **11a** (44.8 g, 0.183 mol) and pyridine (1 mol) was heated at 110–120° for 2.5 hr. The cooled mixture was poured into cold water, extracted with petroleum ether (bp 30–60°), and the combined petroleum ether extracts were washed with 1.8% hydochloric acid (*ca.* 800 ml) and water. The extract was dried and concentrated to afford an oil (39.0 g) containing 2-chloro-1-ethoxy-1-phenyl-1,3-butadiene (**12a**). The oil was dissolved in a solution of acetone (340 ml), water (17 ml), and hydrochloric acid (17 ml) and heated at the reflux temperature for 2.5 hr. Water was added to the cooled mixture and the solution was extracted with petroleum ether. The combined extracts were washed with water, aqueous bicarbonate solution, and dried ($MgSO_4$). The petroleum ether was removed *in vacuo* and the resulting solid was crystallized from petroleum ether to give 19.4 g (60%) of **13a**: mp 70.5–71°; nmr (CCl_4) τ 2.20–2.85 (m, 5, C_6H_5), 3.36 (q, 1, J = 7 Hz, $C{=}CHCH_3$), 8.02 (d, 3, J = 7 Hz, $CHCH_3$); uv max (95% C_2H_5OH) 250 mμ (ε 12,000); ir 1660 and 1620 cm^{-1} (COC=C).

Anal. Calcd for $C_{10}H_9ClO$: C, 66.49; H, 5.02; Cl, 19.63. Found: C, 66.19; H, 5.34; Cl, 19.68.

The 2,4-dinitrophenylhydrazone of 13a was prepared in a solution of methanol and hydrochloric acid and was recrystallized from chloroform–menthanol and ethanol–ethyl acetate to give the pure product (45%): mp 198–200°; uv max (95% C_2H_5OH) 375 mμ (ε 31,000).

Anal. Calcd for $C_{16}H_{13}ClN_4O_4$: C, 53.27; H, 3.63; N, 15.53; Cl, 9.83; Found: C, 53.33; H, 3.41; N, 15.57; Cl, 9.88.

5-Methyl-3-phenylpyrazole.—Reaction of **13a** with hydrazine in ethanol (95%) was exothermic at room temperature and afforded the pyrazole in 74% yield, mp 127–128° [from petroleum ether C, bp 100–105° (lit.[16] mp 127–128°]; the picrate had mp 159° (lit.[16] mp 159°).

1,1-Diethoxy-1-phenylhexane.—The reaction of caprophenone (75 g, 0.43 mol, from caproic anhydride) with ethyl orthoformate in absolute ethanol (58 ml) was carried out[17] with hydrogen bromide and afforded the ketal in 90–95% yields: bp 79–81.5° (0.60–0.65 mm); $n^{25}D$ 1.4750.

Anal. Calcd for $C_{16}H_{26}O_2$: C, 76.99; H, 10.59. Found: C, 76.75; H, 10.47.

1-Ethoxy-1-phenyl-1-hexene.—A solution of 1,1-diethoxy-1-phenylhexane (30 g, 0.12 mol) and *p*-toluenesulfonic acid (0.08 g) was heated with stirring at the reflux temperature for 1.5 hr allowing ethanol to distil. Distillation of the residue afforded the vinyl ether in >90% yield: bp 75–76° (0.45–0.50 mm); $n^{25}D$ 1.5085; ir (neat) 1645 cm^{-1} (C=C).

Anal. Calcd for $C_{14}H_{20}O$: C, 82.30; H, 9.87. Found: C, 82.57; H, 10.05.

3-*n*-Butyl-2,2-dichloro-1-ethoxy-1-phenylcyclopropane (11b).—The method was essentially that described for the preparation of **11a**; however, the crude product could not be purified by distillation since it was thermally unstable. Chromatography of the crude product on silica gel (100–200 mesh) and elution with petroleum ether–benzene (3:1) afforded the nearly pure product. Short-path distillation of a small sample of this material at a bath temperature of 62° (0.002 mm) gave the analytically pure product, $n^{28.5}D$ 1.5090.

Anal. Calcd for $C_{15}H_{20}Cl_2O$: C, 62.72; H, 7.02. Found: C, 62.63; H, 7.07.

2-Chloro-1-ethoxy-1-phenyl-1,3-heptadiene (12b).—The reaction of **11b** (6.00 g, 0.021 mol) with pyridine was carried out essentially as that described for the reaction with **11a**. The crude product was distilled to give 3.27 g (62.5%) of **12b**: bp 92–94° (0.03–0.04 mm); $n^{25}D$ 1.5566; nmr (CCl_4) τ 2.66 (s, 5, C_6H_5), 3.98 (m, 2, CH=CH), 6.38 (q, 2, J = 7 Hz, OCH_2CH_3), 7.98 (m, 2, $C{=}CCH_2$), 8.86 (m, 8, CH_3CH_2 and OCH_2CH_3); uv max (95% C_2H_5OH) 285 mμ (ε 13,000).

Anal. Calcd for $C_{15}H_{19}ClO$: C, 71.84; H, 7.64. Found: C, 71.57; H, 7.87.

The over-all yield of heptadiene **12b** from 1-ethoxy-1-phenyl-1-hexene, without purification (chromatography) of the intermediate cyclopropane **11b**, was 36%. The diene slowly turned into a glass upon standing.

2-Chloro-1-phenyl-2-hepten-1-one (13b).—The hydrolysis of **12b** was effected as described for **12a**. The crude yellow product was distilled to give **13b** in 82% yield: bp 74–83° (0.005 mm); $n^{24}D$ 1.5424; nmr (CCl_4) τ 2.46 (m, 5, C_6H_5), 3.46 (t, 1 $C{=}CHCH_2$ 7.57 (m, 2, $C{=}CCH_2$), 8.58 (m, 4, CH_2), and 9.07 (m, 3, CH_3); ir (neat 1670 and 1615 cm^{-1} (COC=C); uv max (95% C_2H_5OH) 251 mμ (ε 13,000).

Anal. Calcd for $C_{13}H_{15}ClO$: C, 70.11; H, 6.79. Found: C, 69.91; H, 6.82.

The 2,4-dinitrophenylhydrazone of 13b was prepared from the diene and from the ketone in ethanolic hydrogen chloride. Crystallization of the crude product from ethyl acetate afforded the analytically pure hydrazone: mp 163–165°; uv max (95% C_2H_5OH) 374 mμ (ε 28,900).

Anal. Calcd for $C_{19}H_{19}ClN_4O_4$: C, 56.65; H, 4.75; N, 13,91; Cl, 8.80. Found: C, 56.25; H, 4.75; N, 13.98; Cl, 8.95.

Registry No.—**2**, 19689-75-9; **10a**, 19689-76-0; **11a**, 19689-77-1; **11b**, 19713-64-5; **12b**, 19713-65-6; **13a**, 19689-78-2; **13a** (2,4-dinitrophenylhydrazone), 19689-79-3; **13b**, 19689-82-8; **13b** (2,4-dinitrophenylhydrazone), 19689-83-9; 1,1-diethoxy-1-phenylhexane, 19689-80-6; 1-ethoxy-1-phenyl-1-hexene, 19689-81-7.

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The Synthesis of 2-Azetidinones[1a]

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In continuing our search for small-ring heterocycles having biological activity,[2,3] we have synthesized a few *cis*-3-azido-4-aryl-2-azetidinones (I). This Note describes their synthesis and reaction with lithium aluminum hydride. The formation of 2-azidoacetyl-2,4,5-triphenyl-2-imidazoline under modified conditions is also described.

N-Substituted 2-azetidinones have been synthesized by the cycloaddition of azidoacetyl chloride to Schiff bases[4] to yield both *cis* and *trans* isomers, the ratio being dependent on the order of addition of reactants. There is, however, no general method available for the preparation of N-unsubstituted 2-azetidinones. Lack of N substitution has been reported to be a structural requirement[5] for reduction of 2-azetidinones to azetidines which were our ultimate goal. The synthesis of N-unsubstituted 2-azetidinones (I) was achieved by the cycloaddition of acidoacetyl chloride (II) to the corresponding α,α-dibenzylideniminotoluene (hydrobenzamide) (III) in the presence of triethylamine followed by hydrolysis.

(1) (a) From the Ph.D. Thesis of R. E. Lee. (b) To whom all correspondence should be addressed.

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