Investigation of the carbonic acid soluble portion. The carbonic acid extract of the pyrolysis product was made strongly alkaline with sodium hydroxide, extracted with three 100-ml. portions of ether and the ether extract dried over potassium carbonate. Distillation of the ether extract, after removal of the ether, gave 16.3 g. of a water–pyrrolidine mixture, b.p. 78–98°, 4.8 g. of a semi-solid liquid, b.p. 122–169° (1 mm.) and 9.7 g. of tarry residue.

2-(2-Pyrrolidyl)pyrrole (I). The semi-solid liquid, b.p. 122–169° (1 mm.) on several recrystallizations from Skellysolve B gave 3.6 g. of a white crystalline solid, melting at 85.5–86.5°. The solid was basic and gave a positive Ehrlich test for pyrrole.

Anal. Calcd. for $C_8H_{12}N_2$: Neut. equiv., 136. Found: Neut. equiv., 134, 138.

Literature[6] b.p. 94° (0.5 mm.); m.p. 86.3–87.8°.

Picrate of I. Treatment of a solution of I in 95% ethanol with a saturated ethanolic picric acid solution produced a picrate which melted at 170–171° after several recrystallizations from 95% ethanol. Literature[6] m.p. 164–165.5° (uncorrected).

Anal. Calcd. for $C_{14}H_{15}N_5O_7$: C, 46.0; H, 4.2; N, 19.2 Found: C, 46.7; H, 4.2; N, 18.8.

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Rearrangement of 9α-Hydroxy-4-androstene-3,17-dione

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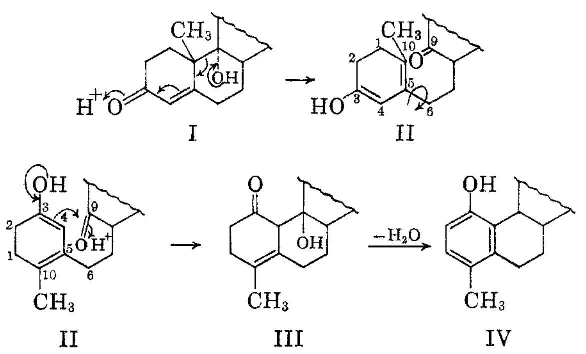
4-Androstene-3,17-dione was shown to be hydroxylated in the 9α-position with a species of Nocardia (A20-10) isolated from soil.[1] We have observed that treatment of the hydroxylated product (I) with pyridine hydrochloride at 218° resulted in a rearrangement to 1-hydroxy-4-methylestra-1,3,5(10)-trien-17-one (IV).[2]

A possible mechanism for this transformation is outlined in the partial formulas (I–IV). The initial step involves a reverse aldol type of reaction, which parallels that previously postulated for the microbiological conversion of 4-androstene-3,17-dione to 9,10-seco-3-hydroxy-1,3,5(10)-androstatriene-9,17-dione,[3] except in the present case the reaction is facilitated by acid. Rotation about the C_5—C_6 bond of II places C_4 in a favorable position to undergo an aldol condensation with the carbonyl group at C_9. Dehydration of the aldol product (III) followed by migration of the resulting double bond into ring A and enolization complete the transformation.



EXPERIMENTAL

A mixture of 1.00 g. of 9α-hydroxy-4-androstene-3,17-dione, m.p. 222–223.5°, and 10 g. of pyridine hydrochloride was maintained at 218° for 50 min. in an atmosphere of nitrogen. The reaction then was cooled, diluted with water, and chilled in an ice bath. The precipitate, which was collected by filtration, washed well with water, and dried, could not be induced to crystallize from ether–petroleum ether (60–68°). The residue remaining after the organic solvents had been removed was chromatographed on 70 g. of silica gel. The column was eluted with varying proportions of benzene–ethyl acetate. Elution with 5% ethyl acetate in benzene gave 404 mg. of a mixture of oil and solid. Two hundred sixty-seven mg. of this mixture was washed free of oil with ether. The solid, which remained, was recrystallized from ether–petroleum ether (60–68°) to afford 57 mg. of colorless massive rods, m.p. 239–248°. Repeated crystallization from ether–petroleum ether (60–68°) raised the m.p. to 251–254°, undepressed by an authentic sample of 1-hydroxy-4-methylestra-1,3,5(10)-trien-17-one (IV).[2,4]

Its infrared spectrum determined in KBr was identical with that of the authentic sample of IV. λ_{max}^{MeOH} 281–286 mμ (ϵ 2250), λ_{min}^{MeOH} 249.5 mμ (ϵ 182); λ_{max}^{KBr} 3.07, 5.82, 6.28, 12.28μ.

Other fractions obtained from the column proved to be intractable tars and resins.

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(1) R. M. Dodson and R. D. Muir, *J. Am. Chem. Soc.*, **80**, 6148 (1958).

(2) (a) A. S. Dreiding, W. J. Plummer, and A. J. Tomasewski, *J. Am. Chem. Soc.*, **75**, 3159 (1953). (b) A. S. Dreiding and A. Voltman, *J. Am. Chem. Soc.*, **76**, 537 (1954).

(3) R. M. Dodson and R. D. Muir, *J. Am. Chem. Soc.*, **80**, 5004 (1958).

(4) We are indebted to Drs. Willard M. Hoehn and Richard A. Mikulec of our laboratory for providing us with a sample of 1-hydroxy-4-methyl-estra-1,3,5(10)-trien-17-one prepared according to ref. 2.

Method for Preparing 2-Aryl-3-aroylpropionitriles

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An attempt was made to prepare 2-phenyl-3-benzoylpropionitrile by treating benzaldehyde with acetophenone and sodium cyanide.[1] The major

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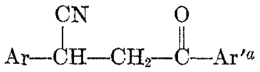
(1) R. B. Davis, *J. Org. Chem.*, **24**, 880 (1959).

TABLE I

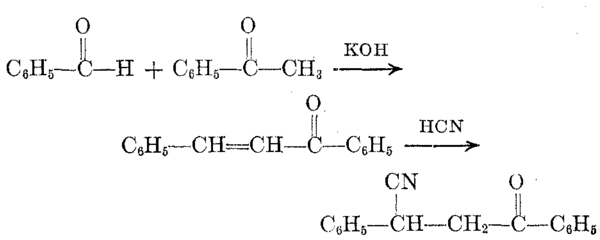


$$Ar-\overset{CN}{\overset{|}{C}H}-CH_2-\overset{O}{\overset{\|}{C}}-Ar'^{a}$$

Ar	Ar′	Yield, %	M.P., °C.[b] Crude	M.P., °C.[b] Recrystd.	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found
C_6H_5	C_6H_5	77–82	124–126	126–127				
p-$CH_3OC_6H_4$	C_6H_5	72	115–117	116–118	76.96	76.94	5.70	5.68[c]
C_6H_5	p-$CH_3C_6H_4$	51	67–69	72–73	81.90	82.24	6.06	5.96[d]
o-ClC_6H_4	C_6H_5	76	106–108	107–109	71.25	71.54	4.48	4.63
p-ClC_6H_4	C_6H_5	89	116–118	117–119	71.25	71.35	4.48	4.49
p-$CH_3OC_6H_4$	p-$CH_3C_6H_4$	67	95–99	103–105	77.39	77.49	6.13	6.22
o-ClC_6H_4	p-$CH_3OC_6H_4$	85	118–120	118–120	68.11	68.25	4.71	4.72

[a] Ar is from the aldehyde, $Ar-\overset{O}{\overset{\|}{C}}-H$. Ar′ is from the aryl methyl ketone, $Ar'-\overset{O}{\overset{\|}{C}}-CH_3$. [b] Melting points are uncorrected. [c] Nitrogen, Calcd. 5.28, found 5.18. [d] Nitrogen, Calcd. 5.62, found 5.74.

product of the reaction, however, was not the expected propionitrile. The preferred method for preparing 2-phenyl-3-benzoylpropionitrile has been by the addition of hydrogen cyanide to benzalacetophenone,[2] which in turn may be prepared by the base catalyzed condensation of benzaldehyde with acetophenone.[3] As was previously reported,[4] we have likewise found that hydrogen cyanide does not add to benzalacetophenone in the absence of a metal cyanide. Likewise the use of sodium or potassium cyanide alone, yields a mixture of products. The best method for adding hydrogen cyanide to benzalacetophenone employs an alkali cyanide and a weak acid such as acetic acid.[2,4] In search of a more convenient procedure for preparing 2-phenyl-3-benzoylpropionitrile, it occurred to us that there is no need to isolate the intermediate benzalacetophenone since it forms in excellent yield[3] in a basic medium. The addition of an excess of hydrogen cyanide to the original reaction mixture seemed, theoretically at least to constitute ideal conditions for the second step in the process.



$$C_6H_5-\overset{O}{\overset{\|}{C}}-H + C_6H_5-\overset{O}{\overset{\|}{C}}-CH_3 \xrightarrow{KOH} C_6H_5-CH=CH-\overset{O}{\overset{\|}{C}}-C_6H_5 \xrightarrow{HCN} C_6H_5-\overset{CN}{\overset{|}{C}H}-CH_2-\overset{O}{\overset{\|}{C}}-C_6H_5$$

When benzaldehyde and acetophenone were reacted in the manner proposed, 2-phenyl-3-benzoylpropionitrile was obtained in 77 to 82% yields. Furthermore it was found that the procedure is general to the extent that other aromatic aldehydes and other aryl methyl ketones can be used. Employing this method a number of new 2-aryl-3-aroylpropionitriles were prepared. Table I will serve to illustrate the versatility of the procedure.

EXPERIMENTAL

Preparation of 2-phenyl-3-benzoylpropionitrile. Twenty-six grams of potassium hydroxide (assay 85%) was dissolved in 400 ml. of absolute acetone-free methanol by heating. The solution was cooled to room temperature on a water bath; 66 g. of acetophenone and then 53 g. of benzaldehyde were added with stirring. Gentle stirring was continued while the water bath was heated at 25–30° for 3 hr. The reaction mixture was then allowed to stand at room temperature overnight.

Hydrogen cyanide (caution[5]) was prepared[6] by adding a solution of 100 g. of sodium cyanide in 200 ml. water to a solution of 200 g. concentrated sulfuric acid in 120 ml. water over 25 min. The hydrogen cyanide evolved was collected in 200 ml. absolute acetone-free methanol cooled on an ice bath. The hydrogen cyanide solution was added to the original reaction mixture described above. While gentle stirring was maintained, the water bath was heated slowly to 50–55°, holding this temperature for 1 hr. Then 150 ml. water was added dropwise with stirring over 20 min. The reaction mixture was allowed to cool, was filtered, and the solid was washed with a solution of two parts methanol and one part water. Upon drying, 91–96 g. (77–82% yield) of 2-phenyl-3-benzoylpropionitrile was obtained, m.p. 124–126°, recrystallized from ethyl alcohol, m.p. 126–127° (lit.[2] 127°).

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[2] G. F. H. Allen and R. K. Kimball, *Org. Syntheses*, **10**, 80 (1930).

[3] E. P. Kohler and H. M. Chadwell, *Org. Syntheses*, **Coll. Vol. I,** 78 (1941).

[4] A. C. O. Hann and A. Lapworth, *J. Chem. Soc.*, **85**, 1355 (1904).

[5] The preparation of hydrogen cyanide and all subsequent operations must be performed in a well ventilated hood.

[6] A. I. Vogel, *"Practical Organic Chemistry,"* Longmans, Green and Co., London, 1954, p. 179.

Condensation of Aromatic Aldehydes with Methyl Aryl Ketones and Sodium Cyanide

R. B. DAVIS

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Previous work has shown that aromatic aldehydes condense with arylacetonitriles and sodium