

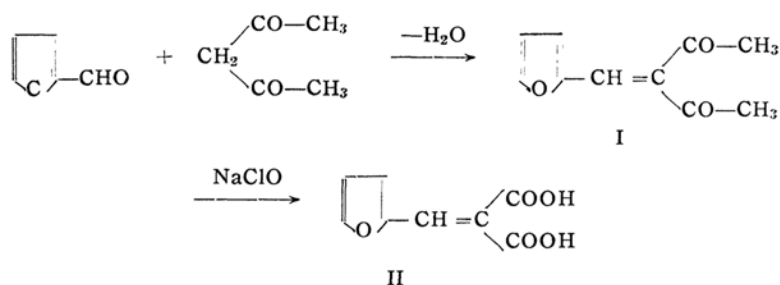
The Condensations of Furfural with Acetylacetone and Ethyl Propionylacetate

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In the present paper were tried the condensations of furfural with acetylacetone and ethyl propionylacetate which have a reactive methylene group. In these cases, piperidine was a more suitable condensing agent than alkali, as in the condensation of ethyl acetacetate with benzaldehyde¹⁾ or furfural²⁾.

The condensation of furfural with acetylacetone by piperidine or aqueous sodium hydroxide gave 3-acetyl-4-(2-furyl)-3-buten-2-one (I), which was oxidised by sodium hypochlorite to furfurylidenemalonic acid (II). The reaction sequence is shown in the following formulae.

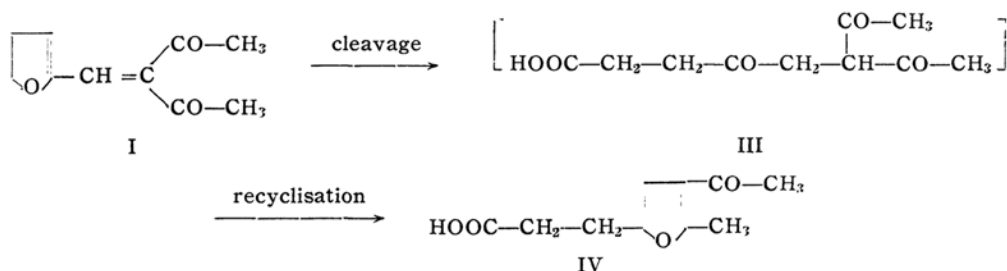


Furthermore, by refluxing with alcoholic hydrochloric acid and subsequent hydrolysis, 3-acetyl-4-(2-furyl)-3-buten-2-one (I) gave an acid, $\text{C}_{10}\text{H}_{12}\text{O}_4$, which gave a semicarbazone, $\text{C}_{11}\text{H}_{15}\text{O}_4\text{N}_3$. It was inferred that this acid

did not possess the group —CH— $\begin{array}{l} \text{COCH}_3 \\ \text{COCH}_3 \end{array}$ and

the ordinary unsaturated nature, because it did not colorise aqueous ferric chloride and did not decolorise bromine water. Consequ-

ently, this compound $\text{C}_{10}\text{H}_{12}\text{O}_4$ was considered to be β -(4-acetyl-5-methyl-2-furyl)-propionic acid (IV) which was given by the ring-cleavage of the furfurylidene ketone (I) and the subsequent recyclisation³⁾ of the resulting cleavage product (III) with loss of water, as illustrated below. The analogous examples had already been reported with respect to furfurylidene-ethyl phenyl ketone⁴⁾ and furfurylidene-(3-methyl-4-methoxy-6-chloroacetophenone)⁵⁾.



In this case the saturated cleavage product (III) was not isolated. The related furan (IV) obtained here showed no remarkable pine-splint reaction.

On the condensation of furfural with ethyl propionylacetate by piperidine was obtained ethyl α -propionyl-2-furanacrylate (V). This compound (V) yielded a dioxocarboxylic acid $\text{C}_9\text{H}_{14}\text{O}_4$ (m. p. 83–84°) on refluxing with alcoholic hydrochloric acid and subse-

1) E. Knoevenagel and W. Ruschhaupt, *Ber.*, **30**, 1026 (1898).

2) E. Knoevenagel, *Ber.*, **23**, 172 (1896).

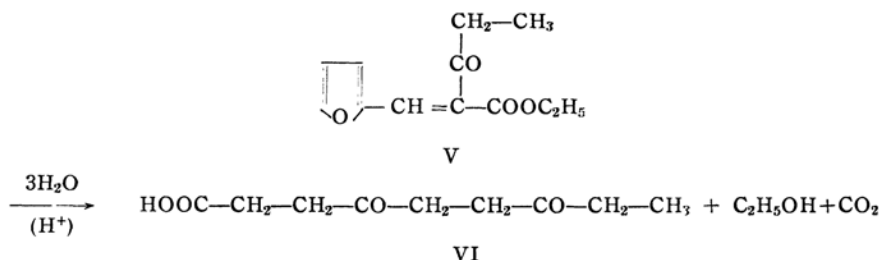
3) A. P. Dunlop and F. N. Peters, "The Furans," p. 653, New York, Reinhold Publishing Corp., (1953).

4) D. L. Turner, *J. Am. Chem. Soc.*, **71**, 612 (1949).

5) R. H. Martin and R. Robinson, *J. Chem. Soc.*, 497 (1953).

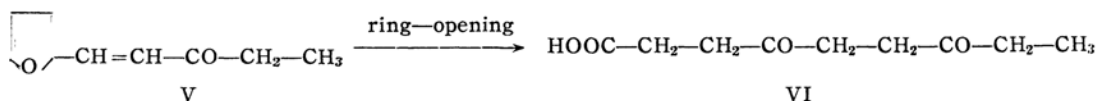
quent hydrolysis. The present author* had already investigated that ethyl α -acetyl-2-furanacrylate yielded γ,ζ -dioxocaproic acid by the

same procedure. It was certain, therefore, that this dioxocarboxylic acid was γ,ζ -dioxopelargonic acid (VI), as illustrated by the following formulation.



In the preceding report⁶⁾, two furfurylidene ketones were obtained on the condensation of furfural with methyl ethyl ketone by alkali. One (b.p. 126°/19 mm.) of those, which gave the two forms of semicarbazone, needles (m.p. 183~184°) and plates (m.p. 166~167°), and the carmine needles (m.p. 206~207°) of 2, 4-dinitrophenylhydrazine, had been considered to be 1-(2-furyl)-penten-3-one (VII), owing to there being no reaction with sodium hypochlorite. The dioxocar-

boxylic acid (m.p. 83~84°) arising from this furfurylidene ketone on the ring-opening in alcoholic hydrochloric acid, which had been expected to be γ,ζ -dioxopelargonic acid, showed no depression on admixture with the authentic specimen (VI) obtained from ethyl α -propioyl-2-furanacrylate (V). Therefore, the considerations in the preceding paper were confirmed. The reaction sequence is illustrated by the accompanying formulation.



Experimental

3-Acetyl-4-(2-furyl)-3-buten-2-one (I). To a mixture of furfural (7 g.) and acetylacetone (7 g.) was added piperidine (0.1 g.) and the vessel was immersed in water at ordinary temperature for 2 days. The reaction mixture was extracted with ether. The ether extract, washed with dilute hydrochloric acid, was dried over calcium chloride. Fractionation of the ethereal solution gave a pale yellow, viscous oil (9 g.) distilling at 128~129°/4 mm., which solidified on standing for a short time. It formed colourless prisms on two recrystallisations from ether, m.p. 58~59°, which was the required ketone (I), $\text{C}_{10}\text{H}_{12}\text{O}_3$. (Found: C, 67.95; H, 5.65%; Calcd. for $\text{C}_{10}\text{H}_{10}\text{O}_3$: C, 67.37; 5.66%).

Its mono-2,4-dinitrophenylhydrazone formed lustrous, carmine prisms melting at 224~225° on crystallisation from pyridine. (Found: C, 53.72; H, 4.06; N, 15.27%; Calcd. for $\text{C}_{15}\text{H}_{14}\text{O}_5\text{N}_4$: C, 53.61; H, 3.94; N, 15.61%).

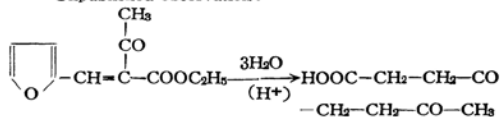
3-Acetyl-4-(2-furyl)-3-buten-2-one (I) (1 g.) was suspended in the sodium hypochlorite solution⁶⁾ (15 cc.) and the vessel immersed in water at

ordinary temperature for 2 days, with occasional shaking. The reaction mixture was acidified with dilute hydrochloric acid and extracted twice with ether. The ether extract on evaporation gave colourless prismatic crystals (2 g.), which were recrystallised from acetic acid as colourless prisms melting at 206° with decomposition. This specimen was identical with furfurylidene malonic acid (II), $\text{C}_8\text{H}_6\text{O}_5$; lit.⁷⁾ m.p. 205°. (Found: C, 52.64; H, 3.32%; Calcd. for $\text{C}_8\text{H}_6\text{O}_5$: C, 52.73; H, 3.32%).

3-Acetyl-4-(2-furyl)-3-buten-2-one (I) (2 g.) was refluxed with conc. hydrochloric acid (1.5 cc.) and alcohol (5 cc.) on the water-bath for 3 hrs. The reaction mixture, after the addition of an equal volume of dilute hydrochloric acid, was evaporated to dryness on the water-bath. The residue was extracted with a sufficient quantity of water, and the extract decolourised by active charcoal. Concentration of the solution on the water-bath gave faintly yellow needle crystals (0.1 g.), which recrystallised from ligroin-ethyl acetate, m.p. 125~126°; soluble in alcohol, benzene and acetone; sparingly soluble in ether. This specimen was considered to be β -(4-acetyl-5-methyl-2-furyl)-propionic acid (IV). (Found: C, 61.21; H, 6.03%; Calcd. for $\text{C}_{10}\text{H}_{12}\text{O}_4$: C, 61.19; H, 6.16%). Molecular weight: Found (Micro-Rast): 198; Calcd. for $\text{C}_{10}\text{H}_{12}\text{O}_4$: 196.

This acid gave a semicarbazone which formed colourless minute crystals (m.p. 206~207°); spar-

* Unpublished observation:



6) H. Midorikawa, This Bulletin, **26**, 460 (1953); **27**, 149 (1954).

7) C. Liebermann, Ber., **27**, 287 (1894).

ingly soluble in methanol. (Found: C, 52.09; H, 5.95; N, 16.53 %; Calcd. for $C_{11}H_{15}O_4N_3$: C, 52.15; H, 5.97; N, 16.59 %).

The condensation of furfural with acetylacetone by alkali was also carried out at 0° . From the reaction mixture was obtained a pale yellow, viscous oil distilling at $127\sim 135^\circ/3$ mm., in a poor yield. This oil did not solidify on standing, but gave the same reaction products as in the case of the condensation product by piperidine—the 2,4-dinitrophenylhydrazone melting at $224\sim 225^\circ$, furfurylidene malonic acid (II) by sodium hypochlorite oxidation and β -(4-acetyl-5-methyl-2-furyl)-propionic acid (IV) on refluxing with alcoholic hydrochloric acid.

Ethyl α -propionyl-2-furanacrylate (V). Into a mixture of furfural (7 g.) and ethyl propionylacetate (10 g.) synthesised by Blaise's method⁸⁾ were introduced five drops of piperidine at -15° . After standing for 24 hrs. at $-15\sim 5^\circ$, five drops of piperidine were added to the mixture, and whole kept at $-15\sim 5^\circ$ for 2 days. The reaction mixture was extracted with ether. The ether extract was washed with dilute hydrochloric acid and dried over calcium chloride. Fractionation of the ether solution gave a pale yellow oil (5 g.) distilling at $147^\circ/5$ mm., which solidified on standing. This fraction recrystallised from ether-ligroin as colourless prisms, m. p. $57\sim 58^\circ$. (Found: C, 64.70; H, 6.10 %; Calcd. for $C_{12}H_{14}O_4$: C, 64.83; H, 6.35 %).

Its 2,4-dinitrophenylhydrazone crystallised from pyridine as scarlet, fibrous needles, m. p. $223\sim 224^\circ$. (Found: C, 53.40; H, 4.34; N, 13.81 %; Calcd. for $C_{18}H_{18}O_7N_4$: C, 53.71; H, 4.51; N, 13.92 %).

γ,ζ -Dioxopelargonic Acid (V). Ethyl α -propionyl-2-furanacrylate (V) (2 g.) was refluxed with conc. hydrochloric acid (2 cc.) and alcohol (5 cc.) on the water-bath for 5 hrs. The reaction mixture, after addition of an equal volume of dilute hydrochloric acid, was evaporated to dryness on the water-bath. The residue was extracted with hot water, and the extract was concentrated on

the water-bath to yield a crystalline mass (0.2 g.) of the required acid. It was recrystallised from ligroin-ethyl acetate as colourless leaflets, m. p. $83\sim 84^\circ$. (Found: C, 57.30; H, 7.28 %; Calcd. for $C_9H_{14}O_4$: C, 58.03; H, 7.59 %).

This acid showed no depression of the mixed melting point with the dioxocarboxylic acid, obtained by the ring-opening of the furfurylidene ketone (b. p. $126^\circ/19$ mm.) in alcoholic hydrochloric acid which was considered to be 1-(2-furyl)-1-penten-3-one in the previous papers⁶⁾.

Summary

3-Acetyl-4-(2-furyl)-3-buten-2-one (I) and ethyl α -propionyl-2-furanacrylate (V) were obtained by the condensations of furfural with acetylacetone and ethyl propionylacetate by piperidine, respectively.

3-Acetyl-4-(2-furyl)-3-buten-2-one (I) was oxidised by sodium hypochlorite to furfurylidene malonic acid (II), and, on refluxing with alcoholic hydrochloric acid and subsequent hydrolysis, gave β -(4-acetyl-5-methyl-2-furyl)-propionic acid (IV).

Ethyl α -propionyl-2-furanacrylate (V) gave γ,ζ -dioxopelargonic acid (VI) by refluxing with alcoholic hydrochloric acid and subsequent hydrolysis.

The dioxocarboxylic acid (m. p. $83\sim 84^\circ$), obtained by the ring-opening of the furfurylidene ketone (b. p. $126^\circ/19$ mm.) in alcoholic hydrochloric acid which was considered to be 1-(2-furyl)-1-penten-3-one (VII) in the previous reports, was identical with this γ,ζ -dioxopelargonic acid (VI). It was confirmed, therefore, that the ideas in the previous reports⁶⁾ was correct.

The author expresses his sincere thanks to Dr. T. Hayashi for his kind advice.

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8) R. Willstätter and C. H. Clarke: *Ber.*, **47**, 298 (1914).