

fied for analysis by recrystallizations from slightly more dilute solutions in this solvent. Water can be added to precipitate the remainder of the ester.

Anal. Calcd. for $C_{15}H_{18}O_4N_2$: N, 9.66. Found: N, 9.52, 9.42.

Summary

1. The pyrimidine methyl N-1-methyl-6-phenyluracil-N-3-acetate has been synthesized by three series of transformations using 6-phenyluracil, 6-phenyl-5,6-dihydrouracil and benzalmethylamine as starting points.

2. The structure of methyl N-1-methyl-6-phenyluracil-N-3-acetate has been definitely established by its synthesis from benzalmethylamine. The structures of the other uracils and hydrouracils have also been proved by relationships to this ester.

3. β -Phenyl- β -aminopropionic acid has been prepared by the reaction of benzaldehyde, malonic acid and ammonium acetate.

4. The preparation of β -phenyl- β -methylaminopropionic acid from benzalmethylamine is evidence that the formation of β -amino acids from ammonia or amines with aldehydes and malonic acid may take place with the intermediate formation of an imine.

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THE DECOMPOSITION OF ETHYL NORMAL-BUTYLACETOACETATE INTO CAPROIC ACID AND METHYL NORMAL-AMYL KETONE

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A number of methods for the preparation of *n*-caproic acid have appeared in the literature from time to time.² Of the various schemes which have been suggested, the synthetic method described in the article mentioned,² starting from ethyl malonate, is the most useful. By use of this method, yields of 74% of the theoretical were obtained.

A synthesis of caproic acid from ethyl *n*-butylacetoacetate is possible and, inasmuch as ethyl malonate has a molecular weight of 160 compared to 130 for ethyl acetoacetate, the acetoacetic ester method appears at first sight attractive. Prices of raw materials are also much in favor of this method.³ Consequently, if satisfactory yields can be obtained, the de-

¹ From a thesis submitted to the Graduate School of the University of Maryland by R. W. Riemenschneider in partial fulfillment of the requirements for the degree of Master of Science.

² See Adams and Marvel, *THIS JOURNAL*, **42**, 317-319 (1920), for a brief summary of these methods.

³ Eastman's "List No. 21" quotes the following: ethyl acetoacetate \$7.00 per kg.; ethyl acetoacetate (pract.) \$3.00 per kg.; ethyl malonate, \$12.00 per kg.; ethyl malonate (techn.) \$10.00 per kg.

composition of ethyl *n*-butylacetoacetate should offer a more economical method of preparing caproic acid than the decomposition of ethyl *n*-butylmalonate.

Considerable quantities of caproic acid were necessary in a research being conducted in this Laboratory, and it was decided, therefore, to study the reaction mentioned above.

Methyl *n*-amyl ketone can be prepared in approximately a 60% yield by the decomposition of ethyl *n*-butylacetoacetate⁴ under appropriate conditions, and the present paper is a report of a series of experiments on factors affecting the yields of this ketone and caproic acid when ethyl *n*-butylacetoacetate is decomposed by alkali.

The effect of varying concentrations of alkali on the decomposition of many mono-substituted ethylacetoacetates has been studied, but ethyl *n*-butylacetoacetate is not among them.

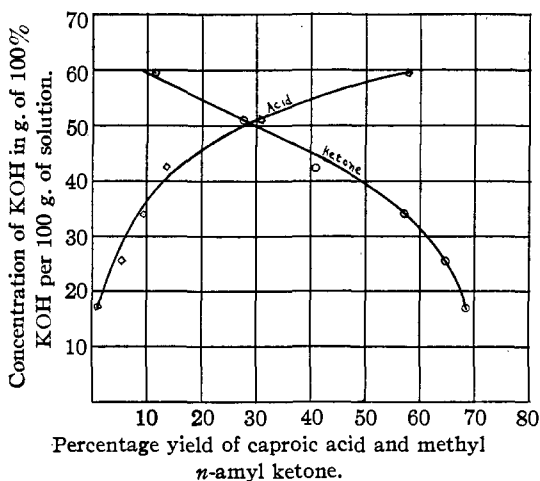


Fig. 1.—The effect of potassium hydroxide concentration on the decomposition of ethyl *n*-butylacetoacetate (T , 105°).

Experimental

Decomposition of the Ester.—In a round-bottomed three-necked flask fitted with a reflux condenser, a mercury-sealed mechanical stirrer and a separatory funnel, were placed the desired amount of water and potassium hydroxide. The reaction flask was then heated to the desired temperature by means of an oil-bath and the ester⁵ added over a period of an hour. The temperature of the oil-bath was read from time to time and the temperatures given in the figures are oil-bath temperatures. Stirring was continued for five hours.

⁴ "Organic Syntheses," John Wiley and Sons, Inc., New York, 1928, Vol. VIII, p. 60; see also "Discussion of Results," below.

⁵ Prepared according to "Organic Syntheses," John Wiley and Sons, Inc., New York, 1927, Vol. VII, p. 36, b. p. 112–117° at 16 mm. pressure.

Isolation of Methyl *n*-Amyl Ketone.—The alkaline reaction mixture was diluted with 250 cc. of water, except in those cases where dilute alkali was used, and the alcohol and ketone which had been produced were distilled off. Distillation was continued until no more water-insoluble material passed into the distillate. The ketone layer was separated, washed twice with one-half its volume of saturated calcium chloride solution and dried over anhydrous calcium chloride. The water layer of the distillate was again distilled until about half its volume of distillate was collected. From this second distillate the ketone was separated and the distillation process repeated until no appreciable amount of ketone separated from the distillate.

Isolation of *n*-Caproic Acid.—The alkaline solution from which the ketone had been distilled was acidified with 50% sulfuric acid, with care not to allow the mixture to become unduly hot during acidification. The caproic acid was then extracted with three 100-cc. portions of ether, the combined extracts dried over sodium sulfate and the ether distilled off on a steam-bath. The sodium sulfate used for drying the extracts was washed with a small portion of anhydrous ether which was added to the dried extract. The crude caproic acid remaining was distilled under reduced pressure from a Claisen flask. The fraction boiling from 105 to 110° under 16 mm. was collected. No appreciable quantity of ketone was obtained during this treatment.

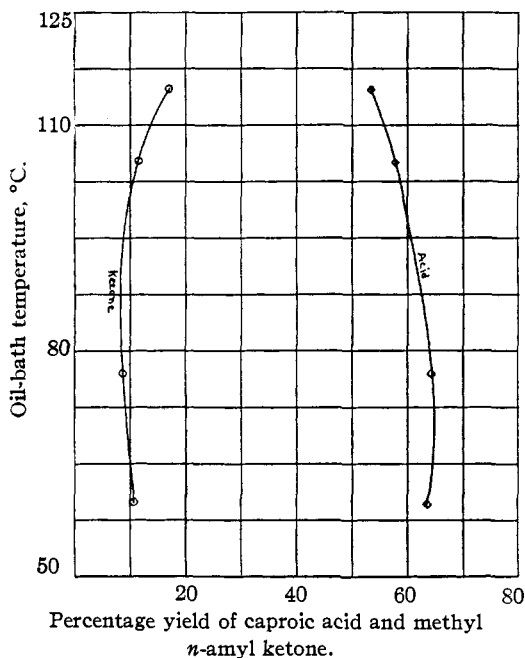


Fig. 2.—The effect of temperature on the decomposition of ethyl *n*-butylacetoacetate (KOH concentration, 59.5 g. per 100 g. of solution).

Discussion of Results

Figure 1 shows the effect of several concentrations of alkali on the yield of ketone and acid. In the six experiments represented by these curves, the oil-bath temperature was 105° and twelve moles of potassium hydroxide per mole of ester was used. Fifty grams of ester was used in each experiment.

Appreciable formation of acid took place only in the more concentrated solutions. It is interesting to note that increasing the alkali concentration from 51 to 59.5 g. of hydroxide per 100 g. of solution caused an increase in yield of acid from 30.5 to 57.7%.

Best yields of ketone were, of course, obtained in the more dilute solutions. The best yield of ketone obtained here was about 8% higher than that mentioned above.

Figure 2 shows the effect of temperature on the decomposition. It can be seen that the temperature of decomposition is not without effect on the yield, although the effect is not great. The optimum temperature for acid production is about 75° . At this temperature an increase in acid yield from 57.7%, the optimum of Fig. 1, to 64.6% was obtained. The experiments represented by Fig. 2 were carried out using 12 moles of hydroxide per mole of ester and a concentration of 59.5 g. of alkali per 100 g. of solution.

Figure 3 represents a series of experiments carried out to determine the effect of decreasing the number of moles of hydroxide per mole of ester.

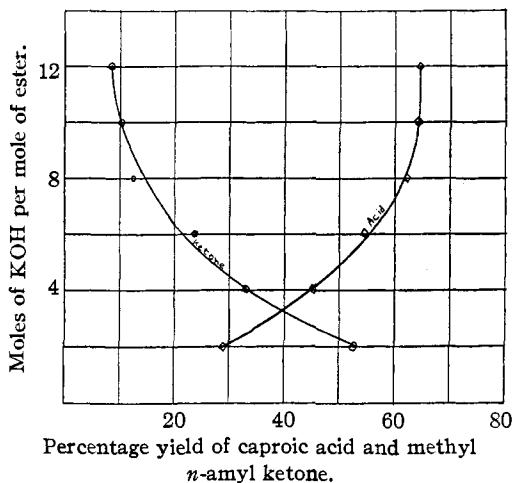


Fig. 3.—The effect of excess alkali on the decomposition of ethyl *n*-butylacetoacetate (oil-bath temperature, 75°).

tion. It is reasonably certain, however, that this period could be considerably shortened. One experiment was conducted in which the time of heating was one hour; the yield of caproic acid was 55.5%. It seemed to us that efficiency of stirring was very important, although no experiments to verify this idea were conducted, and it is believed that with very efficient stirring one hour would have been sufficient to bring the decomposition to completion.

Summary

1. The effects of alkali concentration, excess of alkali and temperature on the decomposition of ethyl *n*-butylacetoacetate have been studied.
2. Formation of caproic acid in satisfactory yield is possible only in very concentrated alkali.

The temperature of the oil-bath was 75° and the initial concentration of alkali 59.5 g. of hydroxide per 100 g. of solution. Little increase in yield of acid was obtained by using more than eight moles of hydroxide per mole of ester, but a decrease below eight resulted in a very considerable drop in acid yield with a simultaneous rise in the yield of ketone.

In all of the experiments mentioned above the stirring of the reaction mixture was continued for five hours to allow the decomposition of ester to proceed to comple-