yield was 1.6 g. (87%). An orange picrate, m.p. 259–260°, and an acetyl derivative, m.p. 354–357°, were prepared from the free base.

b.—Ring closure and acetylation of the amino group in the 7-position were effected by heating 1,6-diamino-2-acetamidonaphthalene (3 g., 0.014 mole) with 15 ml. of glacial acetic acid and 0.3 g. of fused sodium acetate for one hour. When the reaction mixture was made just alkaline to litmus paper with concentrated ammonium hydroxide at 0°, the product separated as a pink gum which was gradually converted to the solid state. It was recrystallized from 95% ethanol as fine pink needles, m.p. 355–356°. No depression of the m.p. was noted when this material was mixed with a specimen of the acetyl derivative reported under (a) above.

Anal. Calcd. for $C_{14}H_{13}ON_3$: N, 17.56. Found: N, 17.44.

The product from the reaction was heated with 20 ml. of concentrated hydrochloric acid for one hour, and 7-amino-2-methylnaphth(1,2)imidazole separated as a hydrochloride. The solid was treated with a concentrated aqueous solution of sodium bicarbonate and the resulting free base recrystallized from dilute ethanol as fine white needles, m.p. 109–110°. The m.p. was raised to 126–128° as in (a) by prolonged drying and no depression was observed when the solid was mixed with a specimen prepared in (a).

An analytical sample was prepared by combining equal weights of 7-amino-2-methylnaphth(1,2)imidazole from (a) and (b) and the mixture dried as outlined. This substance was found to be hygroscopic and special precautions were taken to avoid absorption of moisture during the various analytical manipulations.

Anal. Calcd. for $C_{12}H_{11}N_3$: C, 73.06; H, 5.62; N, 21.31. Found: C, 72.93; H, 5.53; N, 21.12.

7-Chloro-2-methylnaphth(1,2)imidazole (X).—A cold solution of sodium nitrite (0.3 g.) in 1 ml. of water was added dropwise to a suspension of 7-amino-2-methylnaphth(1,2)-imidazole (1 g., 0.004 mole) in 4 ml. of water containing 1 ml. of concentrated hydrochloric acid. The addition which was carried out at 0° required approx. 20 minutes, and vigorous stirring was maintained at all times. The diazonium mixture was slowly poured into a solution of cuprous chloride (0.008 mole) in concentrated hydrochloric acid (8 ml.). The dark mixture was stirred for one hour while the temperature was allowed to rise to 29°, and it was then warmed at 80° for an additional hour. The solid which separated was treated with a warm saturated solution of sodium bicarbonate and the resulting free base recrystallized from dilute ethanol as faintly pink crystals, m.p. 235.5–236.5° in 43% yield (0.4 g.).

Anal. Calcd. for $C_{12}H_9N_2Cl$: C, 66.45; H, 4.19; N, 12.93. Found: C, 66.52; H, 4.02; N, 13.19.

1,5-Diamino-2-acetamidonaphthalene (XI).—1,5-Dinitro-2-acetamidonaphthalene[9] (2.0 g., 0.007 mole) was reduced in acetone solution (75 ml.) by catalytic hydrogenation over Raney nickel catalyst. The solvent was removed by evaporation under reduced pressure and the product recrystallized from 90% ethanol as fine white needles, m.p. 215–217° (dec.), in 70% yield (1.1 g.). The substance failed to undergo ring closure when heated in xylene solution and was recovered unchanged.

Anal. Calcd. for $C_{12}H_{13}ON_3$: N, 19.52. Found: N, 19.39.

The product reacted readily with acetic anhydride in glacial acetic acid solution to give 1,2,5-triacetamidonaphthalene, m.p. 313–314°.

Anal. Calcd. for $C_{16}H_{17}O_3N_3$: N, 14.04. Found: N, 14.18.

6-Amino-2-methylnaphth(1,2)imidazole Hydrochloride (XII).—1,5-Dinitro-2-acetamidonaphthalene (2 g., 0.007 mole) was reduced as above and the product heated at reflux temperature with 10% hydrochloric acid (18 ml.) for one hour. A gray solid separated during the course of the reaction and a second crop of material was obtained by allowing the mixture to stand for 12 hours. The yield of the hydrochloride salt was 1.7 g. When a sample of this substance was treated with an aqueous sodium bicarbonate solution, it was converted into a red gum which failed to solidify even upon prolonged standing. After the salt was recrystallized from 95% ethanol and dried under reduced pressure at 108–110°, it was found that a fraction of the hydrogen chloride had been removed. Results obtained from analyses for nitrogen content corresponded approximately to values required for $C_{12}H_{11}N_3 \cdot {}^1/_2HCl$. This material was then crystallized from 95% ethanol containing a small amount of dry hydrogen chloride and dried under reduced pressure at room temperature. The hydrochloride salt was used to provide an analytical sample.

Anal. Calcd. for $C_{12}H_{11}N_3 \cdot HCl$: C, 61.66; H, 5.13; N, 17.98. Found: C, 61.39; H, 5.35; N, 18.18.

LINCOLN, NEBRASKA RECEIVED MARCH 12, 1951

[CONTRIBUTION FROM THE SHELL DEVELOPMENT COMPANY]

The Alkaline Cleavage of Isophorone

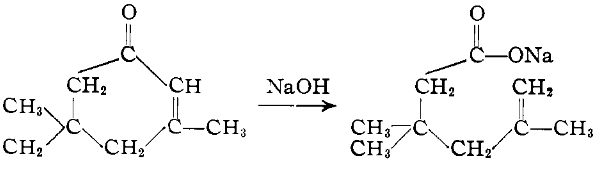
BY H. FINCH, KENNETH E. FURMAN AND SEAVER A. BALLARD

Treatment of isophorone with fused alkali metal hydroxides has been found to yield salts of 3,3,5-trimethyl-5-hexenoic acid in 49% yield. Other products of the reaction include methane, isobutene, acetone, acetic acid and carbonates.

Although a fairly extensive literature is available on the treatment of saturated cyclic ketones with fused alkali,[1,2] relatively little has been reported on the alkaline cleavage of conjugated unsaturated cyclic ketones. Weizmann reported the isolation of 2-cyclohexyl-2-hexenoic acid from the high temperature treatment of cyclohexanol with sodium hydroxide.[3] Pelton[2] isolated 1-cyclohexene-1-caproic acid from the reaction of cyclohexanone with fused sodium–potassium hydroxide. The intermediate in both cases was believed to be a cyclohexenecyclohexanone, or an isomer of this C_{12} unsaturated ketone; however, the material was not isolated nor was the location of the double bond in the C_{12} ketone established.

With the idea of determining whether cleavage at the carbonyl group in the cyclic conjugated unsaturated ketones would occur next to the adjacent saturated or unsaturated carbon atoms, experiments were carried out with isophorone.

The main product obtained by treatment of isophorone with a molten mixture of sodium and potassium hydroxides at 300° was the alkali metal salt of 3,3,5-trimethyl-5-hexenoic acid.



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[1] Guerbet, *Compt. rend.*, **148**, 720 (1909); *Bull. soc. chim.*, **5**, 420 (1909).

[2] Pelton, Starnes and Shrader, THIS JOURNAL, **72**, 2039 (1950).

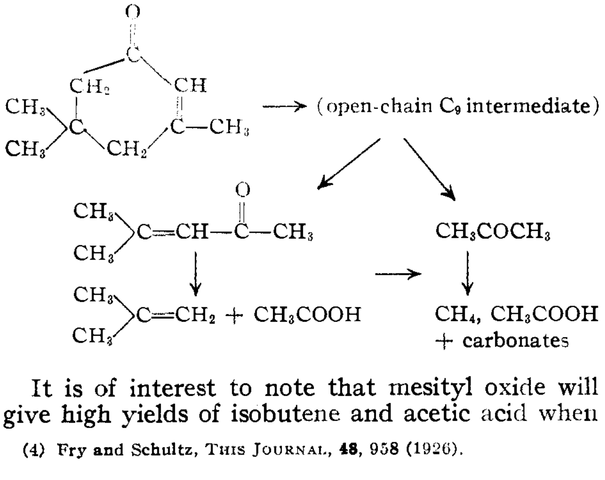
[3] Weizmann, *J. Chem. Soc.*, 772 (1947).

TABLE I

Compound		Boiling point or melting point, °C.	Mm.	Refractive index, n^{20}_D	Saponification value, eq./100 g. Found	Calcd.	Acidity, eq./100 g. Found	Calcd.	Bromine No., g. Br_2/100 g. Found	Calcd.	Carbon, %w Found	Calcd.	Hydrogen, %w Found	Calcd.
3,3,5-Trimethyl-5-hexenoic acid	b	121–122	10	1.4525	...	...	0.629	0.641	126	103	69.35	69.19	10.41	10.33
Methyl ester	b	83.4	20	1.4387	0.587	0.588	...	...	111	94	70.50	70.55	10.65	10.65
Ethyl ester	b	95.8	19	1.4375	0.541	0.543	...	...	98	87	71.63	71.69	10.90	10.94
p-Phenylphenacyl ester	m	88		....	...	...	...	...	...	...	78.6	78.8	7.6	7.5
3,3,5-Trimethylhexanoic acid	b	119–121	10	1.4340	...	...	0.630	0.632	3.2	0.0	68.48	68.31	11.42	11.46
Methyl ester	b	83.0–83.4	20	1.4221	0.588	0.581	...	...	...	...	69.58	69.72	11.74	11.70
Ethyl ester	b	93.0	19	1.4221	0.532	0.536	...	...	0.2	0.0	...	...	...	...
p-Phenylphenacyl ester	m	70		....	...	...	...	...	...	...	78.4	78.4	8.0	8.0

Although this reaction superficially appears to be a simple ionic cleavage between the one and two carbons of the ring, the reactions of alkalies at high temperatures are not well understood and it is possible that the reaction proceeds at least in part by some mechanism other than an ionic one. Of particular interest in this connection is the strong isomerization and dehydrogenation activity of alkali at high temperatures. Regardless of the mechanism it is quite clear from an examination of the products that little, if any, cleavage between the one and six carbon atoms of the ring occurred.

The other compounds isolated from the reaction consisted of mesityl oxide, acetone, acetic acid, isobutene, methane and alkali carbonates. These products would be expected from the reversal of the Aldol and Michael condensations and further reaction of the products with fused alkalies. The composition of the products does not afford any precise evidence as to the first step in the degradation of isophorone but presumably it involves cleavage of the ring to an open chain, nine carbon ketone or diketone, almost certainly either phorone (2,6-dimethyl-2,5-heptadien-4-one), 4,6-dimethyl-3,5-heptadien-2-one or 4,4-dimethyl-2,6-heptanedione. The next step, involving the degradation of these postulated intermediates, would in all cases yield mesityl oxide and acetone, both of which were isolated. Of the remaining decomposition products, methane, acetic acid and carbonates have been shown to be alkaline degradation products of acetone.[4] The fate of mesityl oxide under the original reaction conditions was determined independently. Here it was found that isobutene, acetic acid, acetone, methane and carbonates were produced. The reactions may be summarized as



It is of interest to note that mesityl oxide will give high yields of isobutene and acetic acid when passed together with water over a phosphoric acid catalyst.[5]

Properties of 3,3,5-trimethyl-5-hexenoic acid and its esters are summarized in Table I. The identity of the acid was determined by oxidation with nitric acid to α,α-dimethylsuccinic acid, establishing the structure $-C-C(CH_3)_2-CH_2-C-$, and by optical examination of the methyl ester, indicating the presence of the $CH_2{=}CR_2$ group and the absence of other olefinic types and conjugated unsaturated ester groups. Comparison of the *p*-phenylphenacyl ester of the saturated acid with the authentic ester of 3,5,5-trimethylhexanoic acid indicated that these two materials were different, and therefore the acid could not have been formed by cleavage on the other side of the carbonyl group of isophorone. In addition, reduction of the saturated ethyl ester to a C_9 alcohol, dehydration of the alcohol to a C_9 olefin with sulfuric acid, and hydrogenation of the olefin yielded 2,3,5-trimethylhexane. This product is believed to arise from rearrangement of the neopentylcarbinol 3,3,5-trimethylhexanol or its dehydration products in the presence of an acid catalyst as

$$CH_3{-}CHCH_3{-}CH_2{-}C(CH_3)_2{-}CH_2{-}COOC_2H_5 \xrightarrow{H_2}$$
$$CH_3{-}CHCH_3{-}CH_2{-}C(CH_3)_2{-}CH_2{-}CH_2OH \xrightarrow[\text{and rearrangement}]{-H_2O}$$
$$\left\{\begin{matrix} CH_3{-}CHCH_3{-}CH_2{-}CHCH_3{-}CCH_3{=}CH_2 \\ CH_3{-}CHCH_3{-}CH_2{-}CCH_3{=}CCH_3{-}CH_3 \end{matrix}\right\} \xrightarrow{H_2}$$
$$CH_3{-}CHCH_3{-}CH_2{-}CHCH_3{-}CHCH_3{-}CH_3$$

Experimental

Isophorone and Molten Alkali Hydroxide.—A mixture of 220 g. of potassium hydroxide (87% pellets) and 108 g. sodium hydroxide (98% pellets) was heated in a copper flask to 305°. Isophorone (448 g.) was fed to the flask at a rate of 1.6 ml./min. A total of 1.3 moles of gas (91% methane, mass spectroscopic analysis) was evolved. Material collected in a Dry Ice trap on the exit gas line included 15 g. of isobutene (low temperature distillation and absorption in 65% sulfuric acid), small amounts of acetone (b.p. 56°, carbonyl value, 1.70 eq./100 g., calcd. for C_3H_6O, 1.72) and mesityl oxide (b.p. 125–130°, carbonyl value, 0.98 eq./100 g., calcd. for $C_6H_{10}O$, 1.00). The reaction products were dissolved in water and the solution was acidified (CO_2 was evolved) and extracted with ether. Fractionation of the ether extract gave 250 g. of crude 3,3,5-trimethyl-5-hexenoic acid boiling at 119–124° (10 mm.) (49% conversion) and 95 g. of acetic acid (b.p. 116–118°, eq. wt. 62, calcd. for $C_2H_4O_2$, 60). Refractionation of the C_9 acid gave material with the properties shown in Table I. Properties of esters of the acid, and of the saturated C_9 acid prepared by hydrogenating a 10% aqueous solution of the sodium salt of the unsaturated acid over Raney nickel at 1000 p.s.i.g. and 100° are shown in Table I.

The principal infrared absorption bands of the unsaturated

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(4) Fry and Schultz, THIS JOURNAL, **48**, 958 (1926).

(5) McAllister, Bailey and Bouton, *ibid.*, **62**, 3210 (1940).

methyl ester are listed in Table II. In the spectrum the strong band at 5.77 μ is indicative of an unconjugated ester group. The 6.09 μ band and the band at 11.16 are characteristic of a $CH_2{=}CR_2$ double bond.[6]

TABLE II

INFRARED SPECTRUM OF METHYL 3,3,5-TRIMETHYL-5-HEXENOATE

Wave length, μ,	Intensity[a]
3.39	10
5.77	10
6.09	4
6.79–6.94	10
7.20	1
7.30	3
7.49	10
8.00–8.73	10
8.95	10
9.29	2
9.83	10
10.16	1
10.61	0
11.16	10
11.70	2
12.17	2
13.31	1

[a] Intensity scale from 0 (0–5% absorption) to 10 (95–100% absorption) in cell 0.036 mm. thick.

Hydrogenation of Ethyl 3,3,5-Trimethylhexanoate.—A mixture of 90 g. of ethyl 3,3,5-trimethylhexanoate and 10 g. of copper chromite was hydrogenated at 275° and 2500 p.s.i.g. for 24 hours. Fractionation of the product yielded 62 g. of 3,3,5-trimethylhexanol (b.p. 94.0–95.4° (18 mm.), n^{20}_{D} 1.4345, hydroxyl value, 0.655 eq./100 g., calcd. for $C_9H_{20}O$, 0.694 eq./100 g.).

Preparation of 2,3,5-Trimethylhexane.—A mixture of 37 g. of the C_9 alcohol from above, 11 g. of potassium acid sulfate, and 15 ml. of 50% sulfuric acid was distilled yielding 19 ml. of a hydrocarbon fraction boiling at 125–137°. This was hydrogenated over Raney nickel yielding 12 ml. of 2,3,5-trimethylhexane (b.p. 130–130.5°, n^{20}_{D} 1.4060, sp. gr.$^{20}/_4$ 0.7226; mol. wt. 127; C, 84.30; H 15.71; calcd. for C_9H_{20}: C, 84.28; H, 15.72, reported[7] n^{20}_{D} 1.4061; sp. gr.$^{20}/_4$ 0.7219). The infrared spectrum of the hydrocarbon corresponded to the spectrum of 2,3,5-trimethylhexane.[8]

Oxidation of 3,3,5-Trimethyl-5-hexenoic Acid with Nitric Acid.—The C_9 acid (27 g.) was added dropwise to 500 ml. of boiling 70% nitric acid and the mixture was refluxed for 4 hours. Nitric acid was distilled from the product under reduced pressure, yielding 23 g. of crystalline residue. Recrystallization from water gave 10 g. of α,α-dimethylsuccinic acid (m.p. 139°, mixed m.p. 139°; C, 49.47; H, 6.96; acidity 1.345 eq./100 g.; calcd. for $C_6H_{10}O_4$: C, 49.31; H, 6.90; acidity, 1.369 eq./100 g.).

Reaction of Mesityl Oxide with a Molten Mixture of Sodium and Potassium Hydroxides.—Two hundred seventeen grams of mesityl oxide was added at a rate of 1.5 ml. per minute to a fused mixture of 180 g. of sodium hydroxide and 220 g. of potassium hydroxide in a stainless steel vessel at 300–310°. A total of 1.45 ft.^{3} of non-condensable gas containing 96% *m* methane and 2.9 % *m* butene (mass spectrometric analysis) was formed. Material condensed in a Dry Ice cooled trap included 55 g. of a butylene fraction containing 92.4% *m* isobutene (low temperature distillation and absorption in 65% H_2SO_4) and 64 g. of a mixture of acetone, mesityl oxide and water. Distillation of this latter material yielded 23 g. of acetone (b.p. 55–60°), 14 g. of mesityl oxide (b.p. 125–129°, carbonyl value 0.97 eq./100 g., calcd. for $C_6H_{10}O$ 1.00) and 7 g. of higher boiling material. The solid in the reactor was dissolved in water, filtered, and extracted with ether. Analysis of the water layer indicated the presence of 0.38 mole of carbonates. The water layer was acidified with hydrochloric acid and extracted in a continuous extractor with ether. Distillation of the ether gave 73 g. acetic acid (b.p. 118°, eq. wt. 61, calcd. for $C_2H_4O_2$, 60).

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[6] Rasmussen, *Fortschritte der Chemie organischer Naturstoffe*, *V*, 331 (1948).

[7] API Project 44, Vol. 1.

[8] Serial No. 669, Naval Research Lab., API Project 44.

EMERYVILLE, CALIF. RECEIVED APRIL 17, 1951

[CONTRIBUTION NO. 815 FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF PITTSBURGH]

The Synthesis of Heterocyclic Nitrogen-containing Ketones. I. Ketones Derived from 2-Picoline

BY NEWTON N. GOLDBERG, LLOYD B. BARKLEY AND ROBERT LEVINE

2-Picolyllithium, prepared from 2-picoline and phenyllithium, has been acylated in good yields with methyl benzoate, 2-furoate, 2-thiophenate, acetate, propionate and isovalerate and ethyl benzoate and isobutyrate. In addition to the 2-picolyl ketones, alkyldi-2-picolylcarbinols were isolated in those experiments in which aliphatic esters were used as the acylating reagents.

For several years, we have been interested in this Laboratory in the synthesis of heterocyclic ketones. Some of our results in the thiophene and furan series have been published[1,2,3,4] and we are at present engaged in developing methods for the preparation of heterocyclic nitrogen-containing ketones in high yields. The present paper reports our progress in the 2-picoline series.

Weiss and Hauser[5] have reviewed the literature on the use of the alkali amides for the acylation of 2-picoline, quinaldine and lepidine and have extended these syntheses considerably. 2-Picolyllithium, prepared from 2-picoline and phenyllithium, has been condensed with a number of reagents: benzoyl chloride,[6] benzoic anhydride,[6] acetic anhydride[6,7] propionic anhydride,[7] *n*-butyric anhydride,[7] acetyl chloride,[6,8] acetonitrile,[9] benzonitrile[9] and ethyl acetate.[10] In most cases low yields of ketones were obtained.

Recently, Zelinski and Benilda[11] have studied the acylation of 2-picolyllithium with ethyl benzoate, ethyl 2-furoate and ethyl 2-thiophenate. In the benzoylation of 2-picoline, these workers carried out two experiments. In the first, the following proportions of reactants were used: 0.63 mole of ethyl

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[1] Heid and Levine, *J. Org. Chem.*, **13**, 409 (1948).

[2] Levine, Heid and Farrar, THIS JOURNAL, **71**, 1207 (1950).

[3] Farrar and Levine, *ibid.*, **72**, 3695 (1950).

[4] Farrar and Levine, *ibid.*, **72**, 4433 (1950).

[5] Weiss and Hauser, *ibid.*. **71**, 2033 (1949).

[6] Kloppenburg and Wibaut, *Rec. trav. chim.*, **65**, 393 (1946).

[7] Ruigh, U. S. Patent 2,317,303, April 20, 1943.

[8] Gilman and Towle, *Rec. trav. chim.*, **69**, 428 (1950).

[9] Wibaut and DeJong, *ibid.*, **68**, 485 (1949).

[10] Beets, *ibid.*, **63**, 120 (1944).

[11] Zelinski and Benilda, THIS JOURNAL, **73**, 695 (1951).