

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF MARYLAND]

**Ketene in the Friedel-Crafts Reaction. I. Direct Acetylation of Aromatic Hydrocarbons with Ketene<sup>1</sup>**BY JONATHAN W. WILLIAMS<sup>2</sup> AND JAMES M. OSBORN<sup>3</sup>

The use of ketene in the Friedel-Crafts reaction has been the subject of several studies.<sup>4</sup> In each case reported the yield of methyl aryl ketone has been low. In particular, the yield of acetophenone from benzene and ketene has been reported as 20%, or less.

Results of the present investigation show that the yield of acetophenone from ketene and benzene may be increased above previously reported values by the following considerations: (1) use of a considerable excess of ketene; (2) use of ketene which contains minimum amounts of ethylene and carbon monoxide; (3) operation at 0°; (4) addition of aluminum chloride in small portions with rapid stirring; (5) use of at least 1.5 moles of aluminum chloride per mole of hydrocarbon; (6) use of an inert diluent, as carbon disulfide.

The reaction of ketene and naphthalene can be run so that methyl  $\alpha$ -naphthyl ketone may be obtained to the practical exclusion of the  $\beta$ -isomer. The use of ketene in the Friedel-Crafts reaction has been extended to the reactions with tetralin and diphenyl.

**Experimental Part**

Ketene was generated by the pyrolysis of acetone, using a modification<sup>5</sup> of Ott's ketene lamp<sup>4c,6</sup> with an output of 0.45 mole per hour.

**Acetophenone.**—Ketene was passed into a well-stirred mixture of 100 ml. (1.1 moles) of benzene and 300 ml. of carbon disulfide maintained at 0°. At fifteen-minute intervals approximately 10-g. portions of aluminum chloride were added until 200 g. (1.5 moles) had been used (five hours). Ketene addition and stirring were continued for a total of ten hours (4.5 moles of ketene). The addition complex was decomposed by pouring onto 1 kg. of cracked ice and 30 ml. of concd. hydrochloric acid. After removal of carbon disulfide and benzene from the organic layer, the following fractions were obtained at 22 mm.: (a) 75–105°, 60.1 g.; (b) 105–220°, 30.5 g.; (c) viscous residue, 15 ml. Fraction (a) contained the acetophenone. It was

washed with equal volumes of 5% sodium hydroxide solution and water, dried over sodium sulfate, and redistilled. These fractions were obtained at 12 mm.: (a) 75–83°, 1.3 g.; (b) 83–84°, 44.1 g.; (c) residue, 5 ml. Fraction (b) was pure acetophenone; yield, 32.7%.

**Methyl  $\alpha$ -Naphthyl Ketone.**—The procedure was similar to the preparation of acetophenone, using one mole (128 g.) of naphthalene in 600 ml. of carbon disulfide. These fractions were obtained at 7 mm.: (a) 85–90°, 3.0 g.; (b) 145–151°, 70.0 g.; (c) 151–170°, 7.4 g.; (d) viscous residue, 75 ml. Fraction (a) was unchanged naphthalene (2.4%). Fraction (b) was washed with alkali, then with water, dried over sodium sulfate and distilled. A fraction boiling at 150–151° (7 mm.) weighed 59.1 g. This represented a 34.8% yield of methyl  $\alpha$ -naphthyl ketone.

The ketone was shown to be the  $\alpha$ -isomer by oxidation to  $\alpha$ -naphthoic acid<sup>7</sup> and by conversion to the picrate.<sup>4a,8</sup> Fractional crystallization of the picrate showed that the ketone was largely the  $\alpha$ -isomer, but that a small amount of the  $\beta$ -isomer was present. For the ketone  $n_D^{25}$  is 1.6265.

**Methyl  $\alpha$ -Naphthyl Ketone 2,4-Dinitrophenylhydrazone.**—Prepared by the standard procedure and recrystallized from benzene, this substance melted at 259°. *Anal.* Calcd. for  $C_{18}H_{14}O_4N_4$ : C, 61.71; H, 4.03. Found:<sup>9</sup> C, 61.92, 61.84; H, 4.15, 4.04.

**Methyl  $\beta$ -Tetrahydronaphthyl Ketone.**—The procedure was similar to that for acetophenone, using one mole (136 ml.) of tetralin in 600 ml. of carbon disulfide. These fractions were obtained at 14 mm.: (a) 85–100°, 25.9 g.; (b) 100–152°, 2.4 g.; (c) 152–172°, 59.5 g.; (d) amorphous residue, 60 ml. Fraction (a) represented 19.6% recovered tetralin. Fraction (c) was redistilled at 14 mm.: (a) 152–159°, 1.7 g.; (b) 159–160°, 42.0 g.; (c) 160–168°, 8.8 g.; (d) viscous residue, 5 ml. Fraction (b) represented a 24.1% yield of methyl  $\beta$ -tetrahydronaphthyl ketone. The ketone was characterized by the preparation of the oxime,<sup>10</sup> m. p. 107°, and tetrahydronaphthalene- $\beta$ -carboxylic acid,<sup>10</sup> m. p. 150°, obtained by the action of bleaching powder<sup>11</sup> on the ketone. For the ketone  $n_D^{25}$  is 1.5597.

**Methyl  $\beta$ -Tetrahydronaphthyl Ketone 2,4-Dinitrophenylhydrazone.**—Recrystallized from benzene, the m. p. was 236°. *Anal.* Calcd. for  $C_{18}H_{18}O_4N_4$ : N, 15.82. Found:<sup>12</sup> N, 15.97, 16.02.

**$p$ -Phenylacetophenone.**—Ketene was passed into a solution of one mole (154 g.) of diphenyl in 600 ml. of carbon disulfide at 30° with good stirring for twenty hours (9.0 moles ketene). Two moles (267 g.) of aluminum chloride was added over a ten-hour period. Distillation of the hydrolysis products gave 101.5 g. of material boiling at 140–237° (35 mm.), and which solidified on cooling.

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(3) Taken from the M. S. Thesis of James M. Osborn.

(4) (a) Hurd, *THIS JOURNAL*, **47**, 2777 (1925); (b) Ploeg, *Rec. trav. chim.*, **45**, 342 (1926); (c) Packendorff, Zelinsky and Leder-Packendorff, *Ber.*, **66**, 1069 (1933); (d) Spring and Vickerstaff, *J. Chem. Soc.*, 1873 (1935).

(5) Hurd and Williams, *THIS JOURNAL*, **58**, 965 (1936).

(6) Ott, Schröter and Packendorff, *J. prakt. Chem.*, **130**, 177 (1931).

(7) Kailan, *Monatsh.*, **28**, 1069 (1907).

(8) Stobbe, *Ann.*, **380**, 95 (1911).

(9) Analysis by E. O. Haenni.

(10) Scharwin, *Ber.*, **35**, 2511 (1902).

(11) Hurd and Thomas, *THIS JOURNAL*, **55**, 1646 (1933).

(12) Analysis by L. A. Smith.

It was air-dried and redistilled at 20 mm.: (a) 120–150°, 19.4 g.; (b) 150–195°, 11.9 g.; (c) 195–215°, 51.3 g. Fraction (a) contained 10.7 g. of diphenyl, a 7.0% recovery. Fractions (b) and (c) were recrystallized several times from 95% alcohol and yielded 45.9 g. of *p*-phenylacetophenone, m. p. 121°. This represented a 23.4% yield.

### Summary

Factors influencing the yield of acetophenone

from benzene and ketene have been studied. Conditions have been determined for the preparation of methyl  $\alpha$ -naphthyl ketone to the practical exclusion of the  $\beta$ -isomer. The preparations of methyl  $\beta$ -tetrahydronaphthyl ketone and *p*-phenylacetophenone, using ketene, are reported.

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## alpha,omega-Amino Alcohols. I. N-Phenyl-N'-( $\omega$ -hydroxyalkyl)-piperazines from $\alpha,\omega$ -Chlorohydrins. Derivatives of Piperazine. XVII

BY GEORGE W. ANDERSON<sup>1</sup> AND C. B. POLLARD

Pyman and Levene<sup>2</sup> have synthesized  $\alpha,\omega$ -amino alcohols by the reaction of secondary amines with  $\alpha,\omega$ -chlorohydrins. We have now employed this reaction for the synthesis of a series of N-phenyl-N'-( $\omega$ -hydroxyalkyl)-piperazines.

The general procedure followed was to heat 0.2

obtained in a quantitative crude yield. That of N-phenyl-N'-(4-hydroxybutyl)-piperazine was reduced because of the formation of tetramethylene oxide. Neutral equivalents of the amino alcohols and their phenylurethans and analytical data are recorded in Table I.

TABLE I

N-PHENYL-N'-( $\omega$ -HYDROXYALKYL)-PIPERAZINES OF THE GENERAL FORMULA  $C_6H_5NC_4H_8N(CH_2)_nOH$  AND THEIR PHENYL-URETHANS

| n  | Neutral equivalent<br>(methyl orange) |       | M. p.,<br>°C. (corr.) | Anal., % N |       | M. p.,<br>°C. (corr.) | Phenylurethans |       | Anal., % N |
|----|---------------------------------------|-------|-----------------------|------------|-------|-----------------------|----------------|-------|------------|
|    | Calcd.                                | Found |                       | Calcd.     | Found |                       | Calcd.         | Found |            |
| 4  | 234.3                                 | 236.0 | 59.0–60.0             | 11.96      | 11.81 | 91.0–92.0             | 11.98          | 11.64 |            |
| 5  | 248.4                                 | 248.3 | 74.0–75.0             | 11.28      | 11.13 | 100.0–101.5           | 11.44          | 11.24 |            |
| 6  | 262.4                                 | 262.7 | 65.5–67.0             | 10.68      | 10.52 | 91.5–93.0             | 11.01          | 10.91 |            |
| 7  | 276.4                                 | 274.9 | 75.5–76.5             | 10.14      | 10.06 | 96.5–97.5             | 10.63          | 10.46 |            |
| 8  | 290.4                                 | 292.1 | 57.0–58.5             | 9.65       | 9.43  | 99.5–100.5            | 10.26          | 10.09 |            |
| 9  | 304.5                                 | 303.1 | 80.0–80.5             | 9.20       | 9.14  | 94.0–95.0             | 9.92           | 9.78  |            |
| 10 | 318.5                                 | 317.1 | 67.0–68.0             | 8.80       | 8.74  | 95.0–96.0             | 9.60           | 9.45  |            |

mole of the chlorohydrin with 0.4 mole of N-phenylpiperazine for five hours on a water-bath. The white solid product was heated with 40 cc. of 5 M potassium carbonate, the resulting orange colored oily layer was separated and after it had cooled and solidified, was washed with water and recrystallized from 250 cc. of 60% ethyl alcohol. The white crystals were dried to constant weight in a vacuum over fused potassium hydroxide. Two recrystallizations from ligroin (70–100°) gave a material of constant melting point. The urethans were prepared in hot ligroin solution and were recrystallized from this solvent.

With one exception, the amino alcohols were

(1) This paper is abstracted from a portion of a dissertation submitted by George W. Anderson to the Graduate Council of the University of Florida in partial fulfillment of the requirements for the degree of Doctor of Philosophy, May, 1939.

(2) Pyman and Levene, British Patent 402,159, Nov. 30, 1933, to Boot's Pure Drug Co.

N-Phenyl-N'-(8-hydroxyoctyl)-piperazine readily absorbs water from air to form a monohydrate. The other amino alcohols absorb water less rapidly.

The  $\alpha,\omega$ -chlorohydrins of four and five carbon atoms were obtained in 35% yield by the method of Kirner and Richter.<sup>3</sup> The higher members were prepared in approximately 65% yield by continuous extraction of the reaction mixtures of the corresponding glycols and hydrochloric acid.<sup>4</sup>

Final purification was effected by fractionation at 10 mm. The boiling points of the  $\alpha,\omega$ -chlorohydrins showed a regular increase with increasing number of carbon atoms.

Phenyl- or  $\alpha$ -naphthylurethans were prepared from the chlorohydrins. New urethans prepared were the  $\alpha$ -naphthylurethans of hexamethylene-

(3) Kirner and Richter, *THIS JOURNAL*, **51**, 2503 (1929).

(4) Bennett and Moses, *J. Chem. Soc.*, 1697 (1931).