

**Bis-[(1-methylcyclopropyl)methyl]-durene (VIIIa).**—To a solution of 2.0 g. of VIIa in 200 ml. of liquid ammonia and 200 ml. of ether was added in portions 0.3 g. of sodium until a blue color was observed. After 2 hr. the mixture was treated with 5 g. of ammonium chloride. After the ammonia had evaporated the usual work-up afforded 0.4 g. (50%) of VIIIa, m.p. 103–106° after recrystallization from ethanol and sublimation.<sup>14</sup> A mixture m.p. with VIa was depressed.

When a solution of 1 g. of VIIa in 75 ml. of absolute alcohol was treated with 6 g. of W-2 Raney nickel<sup>17</sup> at reflux for 7 hr., there was obtained 0.2 g. of crude VIIIa, m.p. 100–107°. The same product was obtained by lithium aluminum hydride reduction of VIIa in ether. Several recrystallizations and sublimation afforded pure VIIIa, m.p. 110.0–111.0°.

To a suspension of 4.2 g. of lithium aluminum hydride in 100 ml. of ether was added 19.0 g. of VIIa in 100 ml. of tetrahydrofuran. The mixture was held at reflux for 5 hr. and worked up to yield 6.2 g. (93%) of a hydrocarbon, m.p. 109–111°. Recrystallization from methanol and ethanol afforded the pure compound, m.p. 110–111°, with little loss. At first this compound was believed to be VIa, but mass spectrographic,<sup>14</sup> n.m.r.,<sup>14</sup> and near infrared analyses<sup>29</sup> showed it to be pure VIIIa.

*Anal.* Calcd. for C<sub>20</sub>H<sub>30</sub>: C, 88.8; H, 11.2. Found: C, 88.8; H, 11.2.

(29) P. Gassman, *Chem. Ind.* (London), 740 (1962), reports that compounds having a methylene group in a cyclopropyl ring absorb in the 1.625–1.650  $\mu$  region; VIIIa absorbed at 1.638  $\mu$ .

Of the three methods for preparing pure VIIIa from VIIa, that involving reduction with lithium aluminum hydride appears superior.

**3,3-Dimethylthietane.**—The bismethanesulfonate of neopentyl glycol was prepared essentially as described above for compounds IVa,b,c, in over 90% yield. The purified sample melted at 69–71° after crystallization from methanol.

*Anal.* Calcd. for C<sub>7</sub>H<sub>16</sub>O<sub>6</sub>S<sub>2</sub>: C, 32.3; H, 6.2. Found: C, 32.1; H, 6.1.

The conversion of this methanesulfonate to thietane was carried out as described above for the preparation of compounds Va,b,c, except that the lower boiling thietane was distilled as formed from the reaction mixture and was isolated from the distillate. 3,3-Dimethylthietane,<sup>30</sup> b.p. 115–117°, was obtained in 69% yield (but more was present).

**3-Benzhydrylthietane.**—2-Benzhydryl-1,3-propanediol<sup>31</sup> was converted into the bismethanesulfonate<sup>32</sup> as described<sup>31</sup> in over 90% yield. This compound was used to prepare 3-benzhydrylthietane, m.p. 105.0–107.5°, in 65% yield as described earlier in this paper for compounds Va,b,c. The analytical sample melted at 106.0–108.0° after recrystallization from ethanol.

*Anal.* Calcd. for C<sub>16</sub>H<sub>16</sub>S: C, 79.9; H, 6.6; S, 13.3. Found: C, 79.8; H, 6.6; S, 13.5.

(30) S. Searles, Jr., and F. Lutz, *J. Am. Chem. Soc.*, **80**, 3168 (1958).

(31) M. S. Newman and M. Wolf, *ibid.*, **74**, 3225 (1952).

(32) This compound, colorless needles, m.p. 132–133°, was first prepared by M. Okawara, 1956, in this Laboratory.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, DUKE UNIVERSITY, DURHAM, N. C.]

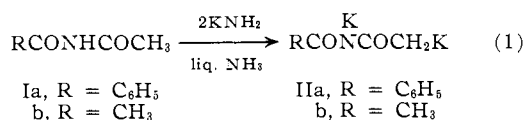
## Condensations at the Methyl Groups of N-Acetylbenzamide and Diacetylimide by Means of Potassium Amide in Liquid Ammonia<sup>1a</sup>

BY STEWART D. WORK, DAVID R. BRYANT,<sup>1b</sup> AND CHARLES R. HAUSER

RECEIVED AUGUST 21, 1963

Condensations at the methyl groups of N-acetylbenzamide and diacetylimide were accomplished through their dipotassio salts IIa-b, which were prepared by means of two molecular equivalents of potassium amide in liquid ammonia. The condensations involved benzylation, benzoylation, and an aldol-type condensation with benzyl chloride, methyl benzoate, and benzophenone, respectively. The benzylations of IIa-b were realized in good yields, although special conditions were required with IIb because of the tendency of its benzyl derivative to cleave. The benzoylations of IIa-b afforded the corresponding benzoyl derivatives, which were cyclized with hydrazine to form 3-phenylpyrazolone-5 (XII) accompanied by elimination of benzamide and acetamide, respectively. The aldol condensation of IIa afforded the corresponding monohydroxyimide XIII in good yield, but that of IIb produced not only monohydroxyimide XIX but also dihydroxyimide XXI and cleavage product XX. These products were dehydrated to give corresponding  $\alpha,\beta$ -unsaturated compounds.

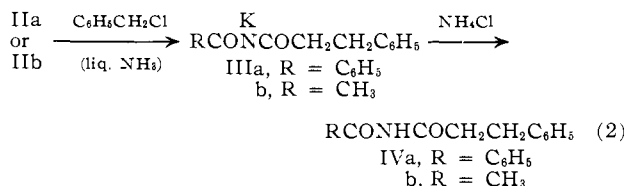
This paper describes three types of condensations at the methyl groups of N-acetylbenzamide (Ia) and diacetylimide (Ib) through their dipotassio salts IIa and IIb, respectively. These salts were prepared by means of two molecular equivalents of potassium amide in liquid ammonia (eq. 1).



These reactions are similar to those observed with benzoylacetone and acetylacetone,<sup>2</sup> to which imides Ia-b are related as nitrogen analogs. Condensations at the  $\alpha$ -carbon of succinimide also have been reported.<sup>3</sup>

**Benzylations of dipotassio salts IIa and IIb** were effected with benzyl chloride to form the C-benzyl derivatives IVa and IVb in yields of 64 and 63%, respectively (eq. 2).

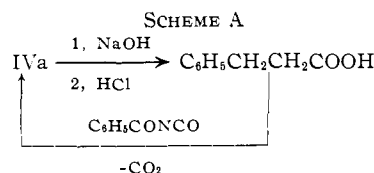
That the alkylation products were IVa-b and not the possible N-benzyl derivatives Va-b was indicated by their solubility in 5% sodium hydroxide solution and by bands in their infrared spectra for the N-H group at



3.05 and 3.14  $\mu$ , respectively.<sup>4</sup>



Structure IVa was confirmed by alkaline hydrolysis to form, besides benzoic acid and ammonia, hydrocinnamic acid, which was employed in an independent synthesis of IVa<sup>5</sup> (Scheme A).



Structure IVb was confirmed by independent syntheses from hydrocinnamamide (VI) and acetic anhy-

(1) (a) Supported in part by the National Institutes of Health; (b) National Science Foundation Predoctoral Fellow (1958–1961).

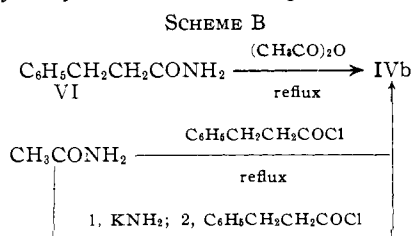
(2) See especially C. R. Hauser and T. M. Harris, *J. Am. Chem. Soc.*, **80**, 6360 (1958); R. B. Meyer and C. R. Hauser, *J. Org. Chem.*, **25**, 158 (1960); R. J. Light and C. R. Hauser, *ibid.*, **36**, 1716 (1961).

(3) D. R. Bryant and C. R. Hauser, *J. Am. Chem. Soc.*, **83**, 3468 (1961).

(4) See L. J. Bellamy, "The Infra-red Spectra of Complex Molecules," 2nd Ed., John Wiley and Sons, Inc., New York, N. Y., 1958, p. 221.

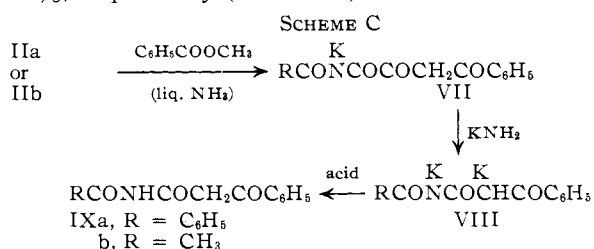
(5) A. J. Hill and W. M. Degnan, *J. Am. Chem. Soc.*, **62**, 1595 (1940); T. B. Johnson and L. H. Chernoff, *ibid.*, **33**, 517 (1911).

dride and from acetamide and hydrocinnamoyl chloride (Scheme B); IVb appears to have been obtained previously only as side reaction product (2% yield).<sup>6</sup>

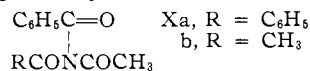


It should be pointed out that the 63% yield of IVb mentioned above was obtained when the benzylation of IIb was effected in the presence of some potassium amide and the reaction mixture neutralized inversely (see eq. 2 and Experimental). When the benzylation was effected in the absence of potassium amide and the reaction mixture neutralized directly (conditions used for IVa), IVb was isolated in only 15% yield after 5 min., and none of IVb was isolated after 1 hr. Under the latter conditions, hydrocinnamamide (VI) was obtained. Presumably VI arose through cleavage of intermediate monopotassium salt IIIb, or of IVb present in equilibrium.<sup>7</sup> Monopotassium salt IIIb, prepared from IVb and potassium amide, underwent cleavage in the absence of, but not in the presence of, some potassium amide under similar conditions (see Experimental).

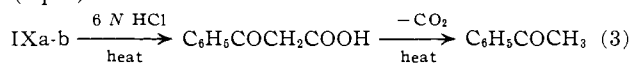
Benzoylations of dipotassium salts IIa and IIb were effected with methyl benzoate in the presence of an extra equivalent of potassium amide to form the C-benzoyl derivatives IXa and IXb in yields of 28 and 13%, respectively (Scheme C).



That the products were IXa-b, not the possible N-benzoyl derivatives Xa-b, was indicated by their solubility in 5% sodium hydroxide solution, by positive enol tests with ethanolic ferric chloride, and by their infrared spectra, which gave bands for the N-H group at 3.07 and 3.04  $\mu$ , respectively.<sup>4</sup>



Structures IXa-b were supported by acid-catalyzed hydrolysis to form, besides the corresponding carboxylic acid, acetophenone, which presumably arose through decarboxylation of intermediate benzoylacetic acid (eq. 3).

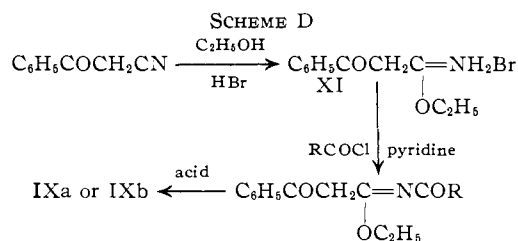


Structures IXa-b were confirmed by independent syntheses from benzoylacetonitrile and the corresponding acid chloride through imino-ester hydrobromide XI (Scheme D).

This method is analogous to that employed previously with the corresponding imino-ester hydrochloride.<sup>8</sup>

(6) H. Burton and D. A. Munday, *J. Chem. Soc.*, 1718 (1957).

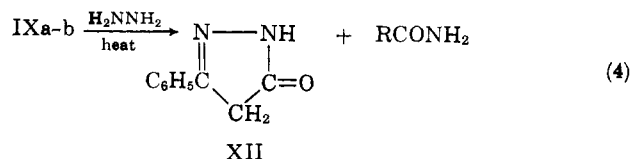
(7) By analogy with the alkaline cleavage of  $\beta$ -diketones (see E. S. Gould, "Mechanism and Structure in Organic Chemistry," Henry Holt and Co., Inc., New York, N. Y., 1959, p. 337) the present cleavage might involve the free imide IVb, and only a catalytic amount of base would be required. However, such imides appear to undergo cleavage much more readily than corresponding  $\beta$ -diketones.



We employed the hydrobromide XI because it has been prepared in better yield than the hydrochloride.<sup>9</sup> Compounds IXa-b have also been obtained by hydrogenation of the appropriate 5-(acylamino)-isooxazole followed by acidic hydrolysis.<sup>10</sup>

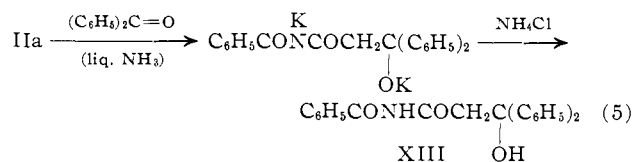
In the benzoylations of dipotassium salts IIa-b (Scheme C), the extra equivalent of potassium amide was used to effect the conversion of the resulting monopotassium salt VII to its dipotassium salt VIII. Although the excess potassium amide probably converted some of the ester to benzamide, the yield of IXa based on the imide Ia was better (28%) than that (10%) isolated when the dipotassium salt IIa was treated with one-half of a molecular equivalent of methyl benzoate.<sup>11</sup> The latter method, in which no excess potassium amide was used, still afforded much benzamide (35%) and also benzoic acid (43%). In this case the benzamide apparently arose through cleavage of the monopotassium salt of imide Ia, which would be generated from IIa in the last step of the condensation reaction.<sup>11</sup> This cleavage would be analogous to that of IIIb mentioned above.

Interestingly, benzoylation products IXa-b underwent cyclization with hydrazine to form 3-phenylpyrazolone-5 (XII) and benzamide or acetamide, respectively (eq. 4).

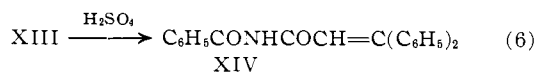


These cyclizations appear to be the first such examples involving the elimination of an acid amide, although the corresponding cyclization of ethyl benzoylacacetate with hydrazine involving the elimination of ethanol is well known.<sup>12</sup>

**Aldol Condensations of Dipotassium Salts IIa-b.**—Dipotassium salt IIa underwent an addition reaction with benzophenone to form hydroxyimide XIII in 75% yield (eq. 5).



Structure XIII was supported by analysis and by its infrared spectrum which showed bands at 2.89 and 3.06  $\mu$  for the O-H<sup>13</sup> and N-H<sup>4</sup> groups, respectively. This structure was established by dehydration to form XIV in 96% yield (eq. 6).



(8) A. Weissberger and H. D. Porter (Eastman Kodak Co.), U. S. Patent 2,439,352 (April 6, 1948); *Chem. Abstr.*, **42**, 4082d (1948). See also J. Klossa, *Arch. Pharm.*, **286**, 397 (1953).

(9) D. J. Morgan, *Chem. Ind. (London)*, 854 (1959).

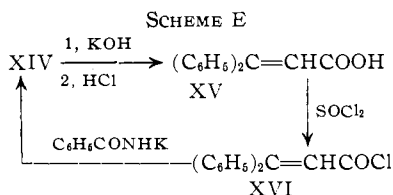
(10) G. Shaw and G. Sugowdz, *J. Chem. Soc.*, 665 (1954).

(11) See R. J. Light and C. R. Hauser, *J. Org. Chem.*, **25**, 538 (1960).

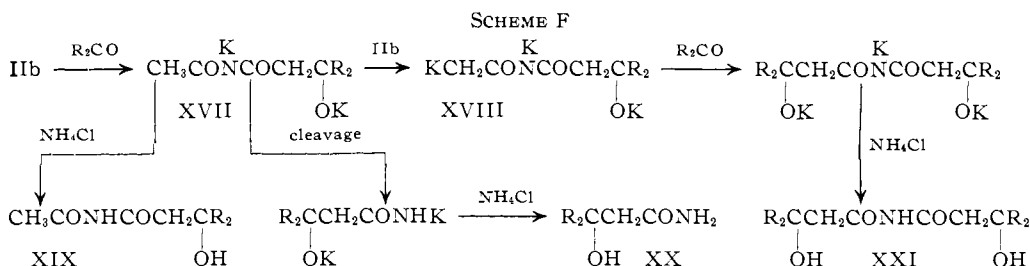
(12) R. von Rothenberg, *J. prakt. Chem.*, **52**, 23 (1895).

(13) See ref. 4, p. 96.

Structure XIV was supported by analysis and by its infrared spectrum which showed a band at  $6.15 \mu$  for the conjugated carbon-carbon double bond,<sup>14</sup> but none in the O-H region. This structure was established by hydrolysis to form, besides benzoic acid and ammonia,  $\beta$ -phenylcinnamic acid (XV), the acid chloride of which (XVI) was employed in an independent synthesis of XIV (Scheme E).



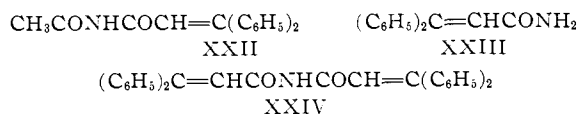
Similarly, dipotassio salt IIb underwent an addition reaction with benzophenone to form monohydroxyimide XIX. However, in contrast to IIa, IIb also afforded dihydroxyimide XXI and cleavage product XX. The formation of these three products is rationalized by Scheme F.



Actually the monohydroxyimide XIX was isolated only when the reaction mixture was acidified almost immediately; its yield was 32%. Even then, approximately as much (31%) of dihydroxyimide XXI and a little (2%) of cleavage product XX were obtained. Surprisingly, the yield of XXI remained about the same (27%) after 2 hr., but that of XX had increased to 24% during this time. Apparently most of XX was produced at the expense of monohydroxyimide XIX.

The formation of dihydroxyimide XXI presumably involved ionization of a methyl hydrogen of the initial intermediate dipotassio salt XVII by the original dipotassio salt IIb to form tripotassio salt XVIII, which added to benzophenone (see Scheme F).

The structures of monohydroxyimide XIX, cleavage product XX, and dihydroxyimide XXI were established by analysis and by dehydration with sulfuric acid to form XXII, XXIII, and XXIV in yields of 90, 79, and 77%, respectively.



Structures XXII, XXIII, and XXIV were supported by analysis. Structures XXII and XXIV were established by hydrolysis to form  $\beta$ -phenylcinnamic acid (XV, 2 moles from XXIV) and ammonia. Presumably XXII also afforded acetic acid.

The structure of XXIII was confirmed by independent synthesis from  $\beta$ -phenylcinnamoyl chloride (XVI), and that of XXIV by independent synthesis from XXIII.

The infrared spectrum of XIX showed bands at 2.87 and  $3.08 \mu$  for the O-H<sup>13</sup> and N-H<sup>4</sup> groups, respectively, whereas the infrared spectrum of XXII exhibited an N-H band at  $3.08 \mu$  and a band at  $6.20 \mu$  for the conjugated carbon-carbon double bond,<sup>14</sup> but no band in

the O-H region. The infrared spectra of XX, XXI, XXIII, and XXIV were inconclusive.

**Synthetic Aspects.**—The three types of condensations described above furnish direct and convenient methods for the synthesis of imide derivatives, several of which are new. Although the yields of some of the products were low, they were generally better than those obtained in the independent syntheses employed.

### Experimental<sup>15</sup>

**N-Acetylbenzamide (Ia) and Diacetyl-imide (Ib).**—Imides Ia<sup>16</sup> and Ib,<sup>17</sup> prepared by known methods in yields of 35–55% and 30–63%, respectively, melted at 116–118° and 77.5–79°, respectively.

**Conversion of Ia-b to Dipotassio Salts IIa-b.**—To a stirred solution of 0.1 mole of potassium amide in 600 ml. of commercial, anhydrous liquid ammonia was added, from an erlenmeyer flask through Gooch tubing, 0.05 mole of finely powdered N-acetylbenzamide (Ia). After stirring for 30 min., the resulting olive green suspension was assumed to contain 0.05 mole of dipotassio salt IIa.

Similarly, dipotassio salt IIb (0.1 mole) was prepared as a white suspension from 0.2 mole of potassium amide in 600 ml. of liquid ammonia and 0.1 mole of diacetyl-imide (Ib).

**Benzoylation of Dipotassio Salt IIa to Form IVa.**—To a stirred suspension of 0.05 mole of IIa in 600 ml. of liquid ammonia was added, during 5 min., 6.96 g. (0.055 mole) of benzyl chloride in 50 ml. of dry ether. The reaction mixture was stirred for 1 hr., and 0.1 mole of solid ammonium chloride was added. The liquid ammonia was evaporated as 250 ml. of ether was added. After adding a mixture of 50 g. of crushed ice and 10 ml. of 12 N hydrochloric acid, the resulting mixture was stirred to dissolve inorganic salts. The precipitate that remained was collected and washed with 25 ml. of ether to give 8.2 g. (64%) of N-benzoyl- $\beta$ -phenylpropionamide (IVa), m.p. 103–105° and 105–106° after recrystallization from ether; reported<sup>5</sup> m.p. 104–105°.

**Hydrolysis of IVa** (2 g.) was effected with 50 ml. of 25% aqueous potassium hydroxide (refluxed 15 hr.); ammonia was evolved. After filtration, the alkaline solution was acidified with 12 N hydrochloric acid. The resulting mixture was extracted with ether. The ethereal extract was dried over anhydrous magnesium sulfate and the solvent removed. The residue (2 g.) was shown to consist of a mixture of hydrocinnamic and benzoic acids, identified by vapor phase chromatographic analysis on an F and M Scientific Corp. Model 500 programmed temperature gas chromatograph, using a 2-ft. silicone gum rubber column and helium as the carrier gas. No other compounds were present. The combined yield of the two acids, assumed to be present in approximately equal amounts, was 93%.

**Independent synthesis of IVa** was effected from 7.1 g. (0.048 mole) of benzoyl isocyanate (b.p. 84–85° at 11 mm.) and 7.3 g. (0.048 mole) of hydrocinnamic acid essentially as described previously<sup>5</sup> (see Scheme A). There was obtained 2.68 g. (21%) of IVa, m.p. 105–106°, undepressed on admixture with a sample of IVa prepared by benzoylation of IIa. The infrared spectra of the two samples were identical.

**Benzoylation of Dipotassio Salt IIb to Form IVb.**—To a stirred suspension of 0.1 mole of IIb and 0.01 mole of potassium amide, prepared from 0.21 mole of potassium amide and 0.1 mole of diacetyl-imide (Ib) in 600 ml. of liquid ammonia, was added 0.11 mole of benzyl chloride in 75 ml. of dry ether. After stirring the reaction mixture for 0.5 hr., the ammonia was evaporated as ether was added, and the resulting ethereal suspension was filtered.

(15) Melting points were taken on a Mel-Temp capillary melting point apparatus and are uncorrected. Infrared spectra were determined with a Perkin-Elmer Model 137 or 237 Infracord by the potassium bromide pellet method. Elemental analyses were by Galbraith Microanalytical Laboratories, Knoxville, Tenn., and by Dr. Ing. A. Schoeller Mikrolabor, Kronach, West Germany.

(16) J. B. Polya and T. M. Spotswood, *Rec. trav. chim.*, **67**, 927 (1948).

(17) D. Davidson and M. Karten, *J. Am. Chem. Soc.*, **78**, 1068 (1956).

(14) See ref. 4, p. 41.

The solid was added to stirred, ice-cold 3 *N* hydrochloric acid, and the resulting mixture was filtered. The solid (16.22 g.) was recrystallized from *n*-hexane to give 12.05 g. (63%) of *N*-acetyl- $\beta$ -phenylpropionamide (IVb), m.p. 104–106° after recrystallization from ether; reported<sup>6</sup> m.p. 107°.

In another experiment, 0.05 mole of benzyl chloride in 50 ml. of ether was added to a stirred suspension of 0.05 mole of dipotassium salt IIb (no excess potassium amide) in 600 ml. of liquid ammonia, followed, after 5 min., by 0.1 mole of ammonium chloride. The ammonia was replaced by ether, and the ethereal suspension stirred with dilute hydrochloric acid. The ethereal layer was dried and most of the solvent removed to precipitate 1.0 g. (15%) of IVb, m.p. 103–105° after recrystallization from *n*-hexane.

**Independent synthesis of IVb** was effected by the three methods indicated in Scheme B<sup>18</sup>; these methods afforded IVb in yields of 4, 2, and 10%, respectively. These samples were shown to be identical with each other and with a sample of IVb from benzoylation of dipotassium salt IIb, by mixture melting points and by infrared spectra. However, admixture of these samples with hydrocinnamamide (m.p. 101–101.5°) depressed the melting point more than 25°.

**Benzoylation of IIb Accompanied by Cleavage to Form VI.**—When 0.1 mole of dipotassium salt IIb (no excess potassium amide) was treated with 0.1 mole of benzyl chloride, and ammonium chloride added after 1 hr. as described for the benzoylation of dipotassium salt IIa, the only product isolated was hydrocinnamamide (VI, 4.55 g., 30%), m.p. 101–101.5° after recrystallization from *n*-hexane–benzene; reported<sup>19</sup> m.p. 100–101°.

*Anal.* Calcd. for C<sub>9</sub>H<sub>11</sub>NO: C, 72.45; H, 7.43; N, 9.32. Found: C, 72.62; H, 7.38; N, 9.16.

**Hydrolysis of VI** (0.50 g.) was effected with 25% aqueous potassium hydroxide (refluxed 12 hr., ammonia evolved). Acidification of the solution precipitated 0.31 g. (62%) of hydrocinnamic acid, m.p. and m.m.p. 47.5–48.5°.

**Independent synthesis of VI** was effected in 65% yield from hydrocinnamoyl chloride and concentrated ammonium hydroxide. After recrystallization from *n*-hexane–benzene, the product melted at 100.5–101°, undepressed on admixture with a sample of VI obtained from IIb and benzyl chloride. The infrared spectra of the two samples were identical.

When the dilithio salt corresponding to IIb (prepared from IIb and two molecular equivalents of lithium amide in liquid ammonia) was treated with benzyl chloride, there was obtained, after 30 min., IVb and VI in yields of 8 and 14%, respectively.

**Cleavage of Monopotassium Salt IIb to Form VI.**—To a stirred solution of 0.015 mole of potassium amide in 250 ml. of liquid ammonia was added 2.86 g. (0.015 mole) of benzyl derivative IVb to form monopotassium salt IIb. After 1 hr., excess ammonium chloride was added, and the ammonia was replaced by ether. The ethereal suspension was shaken with 3 *N* hydrochloric acid, and the layers were separated. After washing with water and sodium bicarbonate solution, the ether layer was dried and the solvent removed. The residue was recrystallized from water to recover 0.43 g. (15%) of IVb, m.p. and m.m.p. 103–105°.

The volume of the aqueous filtrate was reduced to precipitate, on cooling, 1.20 g. (54%) of hydrocinnamamide (VI), m.p. 98–99.5°. Recrystallization from water raised the m.p. to 100–101°, not depressed on admixture with authentic VI (m.p. 101–101.5°).

When 0.025 mole of IVb was added to 0.03 mole of potassium amide in 600 ml. of liquid ammonia and the reaction mixture poured into ammonium chloride in liquid ammonia after 1 hr., there was recovered 92% of IVb, m.p. 101–103.5° and 103.5–105.5° after recrystallization from ether. A mixture melting point with an authentic sample of IVb showed no depression.

**Benzoylation of Dipotassium Salt IIa to Form IXa.**—To a stirred suspension of 0.05 mole each of IIa and potassium amide in 600 ml. of liquid ammonia was added, during 5 min., 13.6 g. (0.1 mole) of methyl benzoate in 100 ml. of dry ether. After 3.5 hr., the ammonia was replaced by ether. The resulting ethereal suspension was poured onto a mixture of 20 ml. of 12 *N* hydrochloric acid and 150 g. of crushed ice to precipitate 2.75 g. of *N*, $\alpha$ -benzoylacetylbenzamide (IXa), m.p. 165–167° and 168–169° after two recrystallizations from 95% ethanol; reported<sup>10</sup> m.p. 168–169°. An additional 0.98 g. of IXa was isolated from the ethereal layer of the filtrate; total yield 28%. The product produced a red enol test with ethanolic ferric chloride solution.

*Anal.* Calcd. for C<sub>15</sub>H<sub>15</sub>NO<sub>3</sub>: C, 71.90; H, 4.91; N, 5.25. Found: C, 72.10; H, 4.87; N, 5.41.

**Hydrolysis of IXa** (0.87 g.) was effected with 40 ml. of 6 *N* hydrochloric acid (refluxed 16 hr.). The reaction mixture was made basic with 1.5 g. of solid sodium hydroxide and then extracted with ether. The ethereal solution was dried over an-

hydrous magnesium sulfate and the solvent removed. The residual oil was dissolved in 10 ml. of 95% ethanol, and 5 ml. of a 0.25 *M* solution of 2,4-dinitrophenylhydrazine in 85% phosphoric acid–ethanol<sup>20</sup> was added. The resulting precipitate was collected to give 0.41 g. (40%) of orange acetophenone-2,4-dinitrophenylhydrazone, m.p. 238–240°, reported<sup>21</sup> m.p. 238–240°. The aqueous alkaline solution that was left after extraction with ether was acidified to precipitate 0.25 g. (61%) of benzoic acid, m.p. and m.m.p. 121–122°.

**Independent synthesis of IXa** was accomplished by treating a solution of 2.72 g. (0.01 mole) of imino-ester hydrobromide XI<sup>9</sup> in 50 ml. of pyridine with 2.81 g. (0.02 mole) of benzoyl chloride in 10 ml. of dry ether. After cooling overnight, the reaction mixture was poured into ice–water and excess acid. There was obtained 0.05 g. (2%) of IXa, m.p. 168–169°, undepressed on admixture with IXa prepared by the benzoylation of IIa. The infrared spectra of the two samples were identical.

**Cyclization of IXa with Hydrazine to Form XII.**—A solution of 1 g. of IXa and 10 drops of 95% hydrazine in 50 ml. of 95% ethanol was refluxed for 1 hr. The reaction mixture was added to 50 ml. of water, and 2 drops of 3 *N* hydrochloric acid was added. After reducing the volume to 20 ml., the solution was cooled to precipitate 0.40 g. (67%) of 3-phenylpyrazolone-5 (XII) m.p. 238–242° and 242–244° after two recrystallizations from 95% ethanol; reported<sup>12</sup> m.p. 236°.

*Anal.* Calcd. for C<sub>9</sub>H<sub>8</sub>N<sub>2</sub>O: C, 67.49; H, 5.03; N, 17.49. Found: C, 67.74; H, 5.13; N, 17.95.

The volume of the filtrate was reduced to 10 ml. to precipitate 0.25 g. (56%) of benzamide, m.p. 122–124° and 126.5–128° after recrystallization from ether. A mixture melting point with an authentic sample of benzamide showed no depression.

**Independent synthesis of XII<sup>12</sup>** was achieved in 90% yield from ethyl benzoylacetate and 95% hydrazine. It melted at 242–244°, undepressed on admixture with a sample of XII prepared from IXa and hydrazine.

**Benzoylation of Dipotassium Salt IIb to Form IXb.**—This reaction was effected essentially as described above for the benzoylation of dipotassium salt IIa in the presence of a molecular equivalent of potassium amide. On replacing the ammonia by ether and pouring the ethereal suspension onto acid and ice, no precipitate formed. The layers were separated. The ethereal layer was extracted with 5% sodium hydroxide solution. The alkaline solution was washed with ether and acidified with hydrochloric acid. The resulting mixture was extracted with ether. After washing with sodium bicarbonate solution, the ethereal solution was dried and the solvent removed. The residue was recrystallized from 95% ethanol to give *N*-acetyl- $\alpha$ -benzoylacetylbenzamide (IXb, 13%), m.p. 93–98° and 104.5–105° after an additional recrystallization; reported<sup>10</sup> m.p. 104°.

**Hydrolysis of IXb** was effected as described above for the hydrolysis of IXa to give acetophenone 2,4-dinitrophenylhydrazone (45%), m.p. 238–240° after recrystallization from acetone–ethanol; reported<sup>21</sup> m.p. 238–240°.

**Independent synthesis of IXb** was accomplished from imino-ester hydrobromide XI,<sup>9</sup> as indicated above for IXa, employing acetyl chloride instead of benzoyl chloride. There was obtained 0.45 g. (22%) of IXb, m.p. 104–105°, undepressed on admixture with a sample of IXb obtained by benzoylation of dipotassium salt IIb.

**Cyclization of IVb with Hydrazine to Form XII.**—This reaction was effected essentially as described above for IXa to give pyrazolone XII (69%). A mixture melting point with an authentic sample of XII showed no depression.

**Condensation of Dipotassium Salt IIa with Benzophenone.**—To a stirred suspension of 0.05 mole of IIa in 600 ml. of liquid ammonia was added, during 5 min., 9.11 g. (0.05 mole) of benzophenone in 50 ml. of dry ether. The original olive green color changed to emerald green and a yellow precipitate formed. After stirring for 2 hr., the reaction mixture was poured into a stirred solution of 10.7 g. of ammonium chloride in 100 ml. of liquid ammonia. The resulting mixture was returned to the original flask, and the ammonia was replaced by ether. The ethereal suspension was stirred with a mixture of 25 ml. of 12 *N* hydrochloric acid and 150 g. of crushed ice. The precipitate was collected and washed successively with 50-ml. portions of water and ether to give 13.0 g. (75%) of *N*-benzoyl- $\beta$ -hydroxy- $\beta$ , $\beta$ -diphenylpropionamide (XIII), m.p. 167–170° and 176–177.5° after recrystallization from ether–ethanol.

*Anal.* Calcd. for C<sub>22</sub>H<sub>19</sub>NO<sub>3</sub>: C, 76.50; H, 5.55; N, 4.07. Found: C, 76.59; H, 5.54; N, 4.18.

**Dehydration of XIII to Form XIV.**—To 60 ml. of stirred concentrated sulfuric acid at 0° was added, in small portions, 6.00 g. of XIII. After most of the solid had dissolved, the reaction mixture was poured onto 150 g. of crushed ice. More (150 ml.) water was added, and the precipitate was collected to give 5.63 g.

(18) The potassio derivative of the acid amide was prepared in liquid ammonia, which was removed before addition of the acid chloride.

(19) J. A. King and F. H. McMillan, *J. Am. Chem. Soc.*, **68**, 632 (1946).

(20) See G. D. Johnson, *ibid.*, **73**, 5888 (1951).

(21) W. Dirscherl and H. Nahm, *Ber.*, **73B**, 448 (1940).

(96%) of *N*-benzoyl- $\beta$ -phenylcinnamamide (XIV), m.p. 160–161.5° after recrystallization from ether–ethanol.

*Anal.* Calcd. for  $C_{22}H_{17}NO_2$ : C, 80.71; H, 5.25; N, 4.29. Found: C, 80.49; H, 5.19; N, 4.33.

**Hydrolysis of XIV** (0.50 g.) was effected with 25 ml. of 25% aqueous potassium hydroxide (refluxed 17 hr., ammonia evolved). After cooling, the alkaline solution was acidified with 12 *N* hydrochloric acid, and the resulting mixture was filtered. The solvent was removed from the filtrate to give 0.33 g. (97%) of  $\beta$ -phenylcinnamic acid (XV), m.p. 156–160° and 160–161.5° after recrystallization from benzene; reported<sup>22</sup> m.p. 162°. A mixture melting point with an authentic sample of XV<sup>23</sup> showed no depression.

The original aqueous acid filtrate of the reaction product was extracted with ether. The ethereal solution was dried and the solvent was removed to give 0.07 g. (37%) of benzoic acid, m.p. and m.m.p. 122–123°.

**Independent synthesis of XIV** was accomplished in 6% yield from  $\beta$ -phenylcinnamic acid (XV)<sup>23</sup> (see Scheme E).<sup>18</sup> It melted at 159.5–160.5°, undepressed on admixture with a sample prepared by dehydration of XIII.

**Condensation of Dipotassio Salt Iib with Benzophenone.**—To a stirred suspension of 0.025 mole of Iib in 250 ml. of liquid ammonia was added 0.025 mole of benzophenone in 75 ml. of dry ether. After 30 sec., the reaction mixture was poured into excess ammonium chloride in liquid ammonia, the ammonia replaced by ether, and the ethereal suspension shaken with hydrochloric acid. The layers were separated. The ethereal layer was dried and the solvent removed. The residue was fractionally crystallized from 95% ethanol to give three compounds. The first compound to precipitate was bis-( $\beta$ -hydroxy- $\beta$ , $\beta$ -diphenylpropionyl)-imide (XXI), m.p. 185–187°; yield 1.80 g. (31% based on benzophenone). Its melting point was raised to 188–190° after two recrystallizations from 95% ethanol.

*Anal.* Calcd. for  $C_{30}H_{27}NO_4$ : C, 77.40; H, 5.85; N, 3.00. Found: C, 77.58; H, 6.12; N, 2.94.

The second compound to precipitate was  $\beta$ -hydroxy- $\beta$ , $\beta$ -diphenylpropionamide (XX), m.p. 211–213°, yield 0.10 g. (2%). Its melting point was raised to 217–218° by two recrystallizations from 95% ethanol.

*Anal.* Calcd. for  $C_{15}H_{15}NO_2$ : C, 74.66; H, 6.27; N, 5.81. Found: C, 75.84; H, 6.27; N, 5.88.

The third compound to precipitate (after removal of most of the solvent) was *N*-acetyl- $\beta$ -hydroxy- $\beta$ , $\beta$ -diphenylpropionamide (XIX), m.p. 128–132°, yield 2.24 g. (32%). Its melting point was raised to 133–134° after two recrystallizations from aqueous ethanol.

*Anal.* Calcd. for  $C_{17}H_{17}NO_3$ : C, 72.06; H, 6.05; N, 4.95. Found: C, 72.03; H, 6.14; N, 4.91.

In another experiment, the reaction mixture was neutralized inversely after 2 hr., and then worked up essentially as described above. Recrystallization of the residue of the reaction product from 95% ethanol precipitated dihydroxyimide XXI (27% based on benzophenone), which was removed by filtration. The solvent was evaporated from the filtrate, and the residue chromatographed on a 1 by 18 in. alumina column to give cleavage product XX (24%), m.p. 213–216° and 217–218.5° after recrystallization from 95% ethanol. None of monohydroxyimide XIX was isolated.

(22) H. Rupe and E. Busolt, *Ber.*, **40**, 4537 (1907).

(23) This acid was prepared in 95% yield from isopropyl  $\beta$ -hydroxy- $\beta$ , $\beta$ -diphenylpropionate (W. R. Dunnivant and C. R. Hauser, *J. Org. Chem.*, **25**, 503 (1960)) by dehydration with 90% formic acid (see W. S. Johnson and H. J. Glenn, *J. Am. Chem. Soc.*, **71**, 1087 (1949)) and saponification of the unsaturated ester. The acid melted at 155–160° and 160–161.5° after recrystallization from benzene.

In still another experiment, 0.05 mole of dipotassio salt Iib in 600 ml. of liquid ammonia was treated with 0.1 mole of benzophenone in 75 ml. of dry ether. The reaction mixture was neutralized inversely with ammonium chloride after 1 hr., and the product was obtained in ether solution as described above. Sufficient solvent was removed to precipitate 3.5 g. (30% based on original imide Ib) of dihydroxyimide XXI. All of the solvent was removed from the filtrate, and the oily residue was worked up to give 3.0 g. (25%) of cleavage product XX and 11.3 g. of recovered benzophenone.

**Dehydration of Monohydroxyimide XIX to Form XXII.**—Dehydration of XIX was effected essentially as described above for the dehydration of XIII to give *N*-acetyl- $\beta$ -phenylcinnamamide (XXII), m.p. 135–137.5° and 138–139° after two recrystallizations from ether–ligroin (b.p. 60–90°); yield 90%.

*Anal.* Calcd. for  $C_{17}H_{15}NO_2$ : C, 76.96; H, 5.70; N, 5.28. Found: C, 77.20; H, 5.71; N, 5.19.

**Hydrolysis of XXII** was accomplished essentially as described above for the hydrolysis of XIV to give  $\beta$ -phenylcinnamic acid (XV), m.p. 156–160° and 160–161.5° after recrystallization from benzene; yield 81%. A mixture melting point with an authentic sample of XV<sup>23</sup> showed no depression.

**Dehydration of Cleavage Product XX to Form XXIII.**—Dehydration of XX was effected essentially as described above for the dehydration of XIII. The milky-white suspension that resulted when the sulfuric acid solution of the product was poured onto ice was extracted with ether. The ethereal layer was washed with water, dried over anhydrous magnesium sulfate, and most of the solvent removed to precipitate pale yellow  $\beta$ -phenylcinnamamide (XXIII); 79% yield, m.p. 150–153° and 154–155° after recrystallization from ether–ethanol; reported m.p. 120°,<sup>24</sup> 130°,<sup>25</sup> and 140–141°.<sup>26</sup>

*Anal.* Calcd. for  $C_{16}H_{13}NO$ : C, 80.70; H, 5.87; N, 6.27. Found: C, 80.60; H, 5.87; N, 6.22.

**Independent synthesis of XXIII** was effected in 75% yield by cautiously adding liquid ammonia to 0.01 mole of  $\beta$ -phenylcinnamoyl chloride (XVI) prepared from  $\beta$ -phenylcinnamic acid (XV)<sup>23</sup> and thionyl chloride. After evaporating excess ammonia, water and ether were added. The ethereal layer was washed with water and dried and the solvent removed. The residue was recrystallized from ether–ethanol to give XXIII, m.p. 154–155°, undepressed on admixture with XXIII prepared by dehydration of XX. The infrared spectra of the two samples were identical.

**Dehydration of Dihydroxyimide XXI to Form XXIV.**—Dehydration of XXI was effected essentially as described for XX to give bis-( $\beta$ -phenylcinnamoyl)-imide (XXIV), m.p. 186–190°; yield 77%. Two recrystallizations from 95% ethanol raised the melting point to 191–192°.

*Anal.* Calcd. for  $C_{30}H_{23}NO_2$ : C, 83.89; H, 5.40; N, 3.26. Found: C, 83.96; H, 5.41; N, 3.15.

**Hydrolysis of XXIV** was accomplished essentially as described for XIV to give a 96% yield of  $\beta$ -phenylcinnamic acid (XV), m.p. 156–160° and 160–161.5° after recrystallization from benzene. A mixture melting point with an authentic sample of XV<sup>23</sup> showed no depression.

**Independent synthesis of XXIV** was accomplished in 16% yield from  $\beta$ -phenylcinnamamide (XXIII) and  $\beta$ -phenylcinnamoyl chloride (XVI) in acetonitrile. It melted at 191–192°, not depressed on admixture with XXIV prepared by dehydration of XXI. The infrared spectra of the two samples were identical.

(24) S. Patai and R. Ikan, *J. Org. Chem.*, **21**, 1379 (1956).

(25) R. Kuhn and G. Platzer, *Ber.*, **73B**, 1410 (1940).

(26) C. Runti and L. Sindarelli, *Boll. chim. farm.*, **99**, 499 (1960); *Chem. Abstr.*, **55**, 10468c (1961).

(27) Earlier workers<sup>25</sup> reported 130° as the melting point for XXIII when it was prepared by this method and recrystallized from acetone.