A sample was recrystallized for analysis from acetone–petroleum ether as needles, m.p. 232–233° dec., $[\alpha]^{26}D$ −46° (*c* 0.95, pyr.).

*Anal.* Calcd. for $C_{36}H_{55}O_{12}N$: C, 62.32; H, 7.99. Found: C, 62.05; H, 8.15.

In a volatile acid determination[21] 26.84 mg. of the compound gave an amount of acid equivalent to 21.70 ml. of 0.005172 *N* sodium thiosulfate; calcd. for 2 mole equivalents of acetic acid and 1 mole of (*l*)-2-methylbutyric acid as expected for structure XVIII, 22.50 ml.

**Acetylation of Protoverine 6,7-Diacetate 15-(*l*)-2'-Methylbutyrate.**—A solution of protoverine 6,7-diacetate 15-(*l*)-2'-methylbutyrate (XVIII, 85 mg., m.p. 223–225° dec.) in pyridine (2 ml.) was treated with acetic anhydride (2 ml.) and the solution was heated on the steam-bath for 90 minutes. The solution was cooled in ice, made alkaline with dilute ammonium hydroxide, and extracted with chloroform. The chloroform extract was dried over anhydrous sodium sulfate and evaporated to yield a resin which was crystallized from acetone–petroleum ether as needles (45 mg.), m.p. 261–262° dec. The melting point was not depressed on admixture with protoverine 15-(*l*)-2'-methylbutyrate 3,6,7,16-tetraacetate (VII). The infrared spectra and paper chromatographic behavior[23a] of the respective samples were identical.

**Sodium Periodate Oxidation of Protoverine 6,7-Diacetate 15-(*l*)-2'-Methylbutyrate.**—A solution of protoverine 6,7-diacetate 15-(*l*)-2'-methylbutyrate (XVIII, 1.45 g.), m.p. 232–233° dec., in 5% acetic acid (50 ml.) was treated with 0.08 *M* sodium periodate (150 ml.) and allowed to stand at room temperature for 150 minutes. The solution was cooled in ice, made alkaline with ammonium hydroxide, and extracted with chloroform. The chloroform extract was dried over anhydrous sodium sulfate and evaporated to yield a resin which was crystallized from ether as rods (800 mg.), m.p. 240–241° dec. A sample was recrystallized for analysis from acetone–petroleum ether as rods, m.p. 241–242° dec., $[\alpha]^{26}D$ +17° (*c* 1.12, pyr.); $\lambda_{max}$ 3.65, 5.62, 5.80 $\mu$.

*Anal.* Calcd. for $C_{36}H_{53}O_{12}N$: C, 62.49; H, 7.72. Found: C, 62.38; H, 7.89.

In a volatile acid determination[21] 24.12 mg. of the compound yielded an amount of acid equivalent to 10.50 ml. of 0.009388 *N* sodium thiosulfate; calcd. for 2 mole equivalents of acetic acid and 1 mole equivalent of *l*-(2)-methylbutyric acid as expected for structure XIX, 11.10 ml.

MADISON 6, WIS.

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[CONTRIBUTION FROM THE CONVERSE MEMORIAL LABORATORY OF HARVARD UNIVERSITY]

# The Synthesis of a Pyrrole Acrylic Lactam

BY WILLIAM C. AGOSTA[1]

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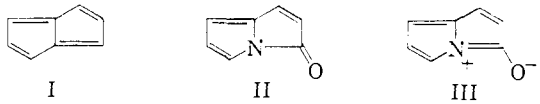
The synthesis of the lactam VI is described. Properties of this compound are discussed in connection with the possibility of an "azapentalene" type structure (*cf.* II ⟷ III).

In recent years numerous efforts have been made to prepare the unknown bicyclo[3.3.0]-octatetraene (I), commonly known as pentalene, or simple derivatives of this system.[2] The compounds which have been synthesized seem to indicate that no special aromatic stability is associated with the pentalene system of unsaturation.[3-5]



I II III

We considered it interesting to investigate the properties of a compound containing the system of II, which is the lactam of pyrrole-2-($\beta$-acrylic acid). In this lactam three of the four pentalene (or in this case "azapentalene") double bonds are present in the well-known vinylpyrrole moiety; the fourth should be formed, should the azapentalene structure be energetically favored, by interaction of the unshared pair of electrons on nitrogen with the adjacent carbonyl group, giving, as the extreme structure, III. Such interaction is of course normal in amides and accounts for the resonance stabilization and planar structure of this functional group.[6]

To synthesize a molecule incorporating the desired features[7] we started with the readily accessible 2,4-dimethyl-3-carbethoxy-5-formylpyrrole (IV).[8] This was condensed with malonic acid in a Knoevenagel reaction to give the $\alpha,\beta$-unsaturated diacid V, as reported by Küster.[9] We found that this substance could be cyclized and decarboxylated in rather low yield (20–37%) by treatment with re-

(1) Department of Chemistry, University of California, Berkeley 4, Calif.

(2) For a review of this work see W. Baker and J. F. W. McOmie, in *Prog. in Org. Chem.*, **3**, 68 (1955).

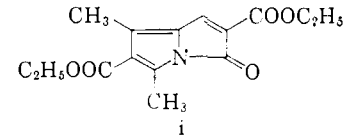
(3) C. T. Blood and R. P. Linstead, *J. Chem. Soc.*, 2263 (1952).

(4) H. J. Dauben, V. R. Ben and S. H.-K. Chiang, Abstracts of Papers, 123rd Meeting, Am. Chem. Soc., Los Angeles, Calif., March, 1953, p. 9-M.

(5) Since the completion of this work the syntheses of a benzazapentalene, a dibenzazapentalene and two naphthbenzazapentalenes have been announced by W. Treibs (*Naturwiss.*, **46**, 170 (1959)). These interesting compounds are briefly reported to possess "all properties of non-benzenoid aromatics."

(6) (a) L. Pauling, "The Nature of the Chemical Bond," 2nd edition, Cornell University Press, Ithaca, N. Y., 1948, p. 133; (b) R. B. Woodward, "The Chemistry of Penicillin," Princeton University Press, Princeton, N. J., 1949, p. 443; (c) S. Mizushima, T. Simanouti, S. Nagakura, K. Kuratani, M. Tsuboi, H. Baba and H. Fujioka, THIS JOURNAL, **72**, 3490 (1950); (d) R. J. Kurland, *J. Chem. Phys.*, **23**, 2202 (1955).

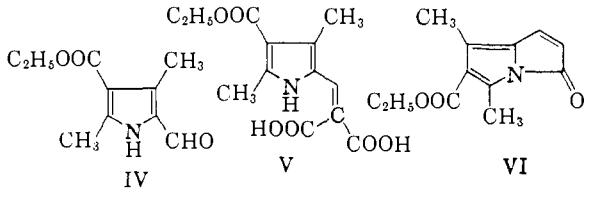
(7) Over thirty years ago Küster described the preparation of a pyrrole acrylic lactam closely related to the one presented here (W. Küster, E. Brudi and G. Koppenhöfer, *Ber.*, **58**, 1014 (1925)). A compound obtained by refluxing an absolute methanolic solution of the diacid V for 60 hours was assigned structure i on the basis of carbon and hydrogen analysis, molecular weight determination and its lack of acidic properties. It was isolated as yellow platelets on cooling the reaction mixture. We have attempted unsuccessfully to repeat this reaction both under the original conditions and with organic acid catalysis. Infrared examination of the reaction mixtures gave no evidence of the reported product. Further it seems to us unlikely that the crystalline material reported by Küster could have this structure (i). We would not expect lactamization and esterification of the malonic acid to proceed in absolute methanol to give the 60% yield recorded.



i

(8) See Experimental.

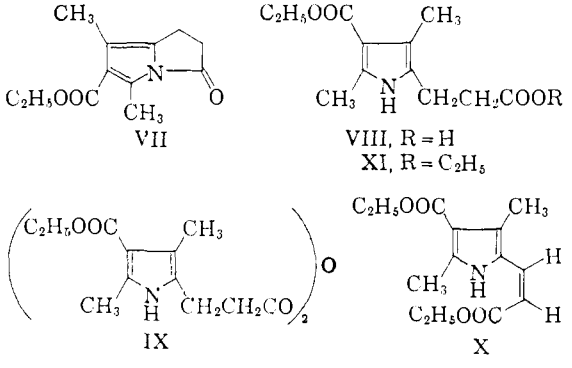
(9) See reference in footnote 7.



IV V VI

fluxing acetic anhydride. The bright red-orange crystalline product is shown by the reactions described below to be the lactam of 2,4-dimethyl-3-carbethoxypyrrole-5-($\beta$-acrylic acid) (VI).

On catalytic reduction the red compound absorbed 94% of one mole of hydrogen to give a colorless crystalline substance which was identical with a sample of the lactam of 2,4-dimethyl-3-carbethoxypyrrole-5-($\beta$-propionic acid)(VII), obtained in an independent synthesis from the corresponding acid. This acid[10] (VIII) on treatment with boiling acetic anhydride gave the symmetrical anhydride IX, which was converted into the desired lactam by heating with acetic anhydride containing freshly fused potassium acetate.[11] Conversion of the propionic acid directly to the lactam could be realized under these latter conditions, but in poorer yield.



VII VIII, R = H; XI, R = $C_2H_5$ IX X

Additional evidence supporting the acrylic lactam structure for the red product is its solvolysis in ethanolic sodium ethoxide. This reaction leads to the nicely crystalline pyrrole *cis*-acrylic ester X, the structure of which was apparent from its catalytic reduction. The hydrogenation yielded the corresponding propionic ester XI, which was also available by esterification of the authentic propionic acid. The acrylic ester must have the *cis* configuration since its infrared spectrum contains no band associated with a *trans* disubstituted double bond carbon–hydrogen out-of-plane deformation (approximately 10.3 $\mu$).[12–14]

These reactions, taken with the physical data presented below, constitute proof that the red product does possess structure VI and also appear strongly to indicate that this compound has no extra stability (beyond that of a simple pyrrole) attributable to azapentalene resonance (II ⟷ III). The hydrogenation of this lactam proceeds quickly under quite mild conditions—in benzene solution with 10% palladized charcoal as catalyst. The double bond $\alpha,\beta$ to the amide carbonyl reacts as an entity separate from those of the original pyrrole ring, which is aromatic in its own right. Likewise the cleavage of the lactam with ethoxide evidences no extra stabilization for the bicyclic system. Although the compound may be dissolved in absolute ethanol to give a red-orange solution, the color fades immediately if the solution is made 0.67 molar in sodium ethoxide. Since the saturated lactam also undergoes rapid solvolysis under these conditions, we have determined the rates of these two reactions under controlled conditions. If there is extra resonance stability of the acrylic lactam over the saturated analog, it should undergo solvolysis more slowly.[6b,15] In fact, however, the apparent first-order rate constants in 0.0002 molar ethoxide for the two compounds are not significantly different. The unsaturated lactam VI indeed is slightly more rapidly cleaved, with a rate constant of 0.31 min.$^{-1}$, compared with 0.17 min.$^{-1}$ for the saturated compound VII.

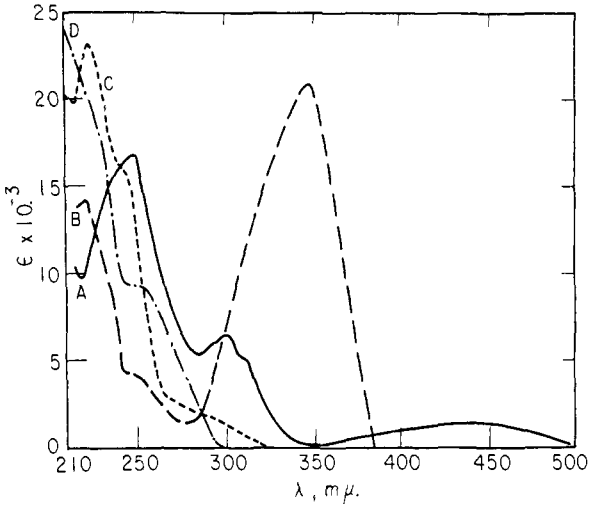



Fig. 1.—Ultraviolet spectra: A, VI in cyclohexane; B, X in 95% ethanol; C, VII in cyclohexane; D, XI in cyclohexane.

We should also mention the absorption spectra of these compounds in connection with this question of azapentalene aromaticity. The infrared region might provide an indication of aromatic character, since in simple cases carbonyl stretching vibration frequency is dependent upon the degree of polarization of the carbon–oxygen double bond.[16] This frequency would then be a convenient qualitative measure of the relative contributions of the nonpolarized and polarized forms, II and III, to the structures of the lactams. If this relationship

(10) H. Fischer and E. Bartholomäus, *Ber.*, **45**, 1925 (1912).

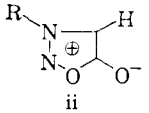
(11) H. Fischer and M. Neber, *Ann.*, **496**, 18 (1932).

(12) R. S. Rasmussen, R. R. Brattain and P. S. Zucco, *J. Chem. Phys.*, **15**, 135 (1947).

(13) J. L. H. Allan, G. D. Meakins and M. C. Whiting, *J. Chem. Soc.*, 1874 (1955).

(14) The known isomeric ester prepared by Küster (reference in footnote 7) presumably, therefore, possesses the *trans* configuration.

(15) *Cf.* the resistance of the *meso*-ionic sydnones (ii) to hydrolysis compared with normal $\gamma$-lactones; J. C. Earl and A. W. Makney, *J. Chem. Soc.*, 899 (1935); W. Baker, W. D. Ollis and V. D. Poole, *ibid.*, 1542 (1950).

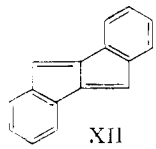


ii

(16) A. H. Soloway and S. L. Friess, THIS JOURNAL, **73**, 5000 (1951).

does obtain for these pyrrole lactams,[17] the infrared data corroborate the above chemical evidence. The acrylic lactam absorbs at 5.76 $\mu$, while the hydrogenated product has its band at 5.68 $\mu$. The carbonyl bands in both compounds are then at rather high frequencies for amides, presumably resulting from much less than normal resonance with the nitrogen lone pair of electrons.[18] This unshared pair seems in both cases to be bound quite firmly in the resonance of the pyrrole ring itself. Thus neither chemical nor infrared results reveal any special azapentalene stabilization in VI.

The ultraviolet and visible absorption spectra provide the only demonstration that any unusual electronic interaction exists in this system. While there are differences in the location of the principal pyrrole bands (in the 220–290 m$\mu$ region)[19] of the acrylic lactam compared with either the saturated lactam or the unsaturated ester, the most striking differences are in the region above 300 m$\mu$. The saturated lactam and saturated ester, on the other hand, have reasonably similar electronic spectra above 210 m$\mu$. The other two compounds containing the 3-carbethoxy-5-($\beta$-carbonylvinyl)-pyrrole chromophore—the unsaturated ethyl ester X and the malonic acid V—both show strong absorption in the near ultraviolet. The former has $\lambda_{max}$ 346 m$\mu$ ($\epsilon$ 20950) and the latter, with an extra carbonyl conjugated with the vinylpyrrole, has $\lambda_{max}$) 376 m$\mu$ ($\epsilon$ 35000). This absorption is completely absent in the acrylic lactam. Instead it shows a broad band of low intensity, $\lambda_{max}$ 439 m$\mu$ ($\epsilon$ 1660), accounting for its bright red-orange color. Such absorption must denote some electronic interaction lacking in the other compounds and therefore stands as the only evidence for an unusual electron distribution in this molecule. The evidence is reminiscent of that of Blood and Linstead concerning the bronze-colored dibenzpentalene XII.[3] Neither compound displays chemical reactions or stability attributable to pentalene aromaticity, but each has a rather unexpected, low-energy electronic transition.



XII

**Acknowledgment.**—It is a pleasure to record here our appreciation of the guidance and direction given to this work by Professor R. B. Woodward.

## Experimental[20]

**2,4-Dimethyl-3-carbethoxy-5-($\beta$,$\beta$-dicarboxyvinyl)-pyrrole (V).**—The diacid was prepared essentially as directed by Küster.[21] Two grams of formylpyrrole IV[22] and 2.0 g. of malonic acid were dissolved in 100 ml. of absolute ethanol containing 2.0 ml. of diethylamine and the solution refluxed 24 hours under nitrogen. Only a small amount of product precipitated on cooling, contrary to Küster's experience, and the following procedure was found most effective for purification of the rather labile product. The solution was allowed to cool and was then diluted with about 120 ml. of water and acidified with 5 *N* sulfuric acid. Immediately a yellow, amorphous, finely divided precipitate formed. The entire mixture was transferred to tubes and centrifuged. The supernatant was discarded and the powder washed with ethanol until the liquor remained colorless after centrifugation, then several times with ether, and was dried *in vacuo;* yield 85%. The centrifugation is preferable to filtration since the material is quite finely divided and air sensitive.

The acid thus prepared darkened slowly *in vacuo* at 195–205°, finally decomposing with evolution of gas. It was customarily used as this yellow powder, but could be obtained in crystalline form by prolonged heating with methanol. The powder dissolves slowly and is then precipitated as green needles by cooling and concentration of the solution. These needles decompose with gas evolution at 214–215°. The infrared spectra in potassium iodide pellet of the powder and of the needles are identical, showing carbonyl absorption at 5.81 and 5.92 $\mu$.

**Lactam of 2,4-Dimethyl-3-carbethoxypyrrole-5-($\beta$-acrylic Acid) (VI).**—One gram of the above unsaturated malonic acid was added to 45 ml. of boiling acetic anhydride and the solution refluxed one hour under nitrogen. The solution turned deep red in the first few minutes of heating. After cooling, the acetic anhydride was removed *in vacuo* at room temperature to leave a red-brown mass containing crystals. This was extracted with a small volume of cyclohexane and the resulting concentrated solution chromatographed over 2.0 g. of no. 5 Woelm alumina. An orange band was eluted with 2:1 cyclohexane–benzene. On removal of solvent there remained a crystalline mass, m.p. 122–124°. Several recrystallizations from cyclohexane gave an analytical sample of red prisms, m.p. 125.8–126.4°. Yields varied from 20 to 37%. The infrared spectrum showed carbonyl bands at 5.76 and 5.86 $\mu$; N–H absorption was absent.

*Anal.* Calcd. for $C_{12}H_{13}O_3N$: C, 65.74; H, 5.98; N, 6.39. Found: C, 65.54; H, 6.19; N, 6.60.

**Lactam of 2,4-Dimethyl-3-carbethoxypyrrole-5-($\beta$-propionic Acid) (VII) by Hydrogenation of VI.**—One hundred milligrams of unsaturated lactam was dissolved in 30 ml. of dry benzene and 5 mg. of 10% palladium-on-charcoal added. This solution absorbed 94% of one mole hydrogen at 25° (1 atm.) within 20 minutes. After removal of catalyst and solvent there remained a colorless crystalline mass. Recrystallization from cyclohexane gave an analytical sample, m.p. 116°; yield after one recrystallization, 77%.

*Anal.* Calcd. for $C_{12}H_{15}O_3N$: C, 65.14; H, 6.83. Found: C, 64.91; H, 7.01.

The authentic sample of this compound (*vide infra*) was analyzed for carbon, hydrogen and nitrogen. The two samples had identical infrared spectra, with carbonyl absorption at 5.68 and 5.81 $\mu$. N–H absorption was absent.

**2,4-Dimethyl-3-carbethoxypyrrole-5-($\beta$-propionic Anhydride) (IX).**—Five hundred milligrams of the substituted propionic acid *VIII* (m.p. 119.4–120°, reported[9] m.p. 119–120°) was dissolved in 12 ml. of acetic anhydride and refluxed 2.5 hours. Within five minutes the reaction mixture turned quite dark and then faded to light brown. On cooling to room temperature the solution became purple. The acetic anhydride was removed with slight heating at 0.4 mm. pressure to give a purple oil which crystallized on trituration with ether. Filtration from the ether solution gave almost colorless crystals; yield 79%. Numerous recrystallizations from benzene gave an analytical sample, m.p. 148–149° dec. The infrared spectrum showed typical anhydride

(17) This criterion of charge separation must be regarded with some care, for in compounds of unusual structure it can fail completely. For example, the sydnones, which from dipole moment studies are best represented as ii, show carbonyl absorption in the range 5.65–5.81 $\mu$; W. Baker and W. D. Ollis, *Quart. Revs.*, **11**, 22 (1957).

(18) *Cf.* the absorption of $\gamma$-butyrolactam at 5.88 $\mu$; H. M. Randall, N. Fuson, R. G. Fowler and J. R. Dangl, "Infrared Determination of Organic Structures," D. Van Nostrand Co., Inc., New York, N. Y., 1949, p. 162.

(19) G. K. Cookson, *J. Chem. Soc.*, 2789 (1953).

(20) Microanalyses by Schwarzkopf Microanalytical Laboratory, Woodside, N. Y. Melting points are corrected. Infrared spectra were determined using Perkin–Elmer model 21 recording spectrophotometer and were in carbon tetrachloride solution unless otherwise noted.

(21) See reference in footnote 7.

(22) H. Fischer and W. Zerweck, *Ber.*, **55**, 1942 (1922). 2,4-Dimethyl-3-carbethoxy-5-carboxypyrrole was decarboxylated and the product formylated by the methods of E. J. Chu and T. C. Chu, *J. Org. Chem.*, **19**, 266 (1954).

carbonyl absorption at 5.52 and 5.75 $\mu$, and N–H absorption at 2.78 $\mu$.

*Anal.* Calcd. for $C_{24}H_{32}O_7N_2$: C, 62.59; H, 7.00; N, 6.08. Found C, 62.94; H, 7.13; N, 6.21.

**Authentic Lactam of 2,4-dimethyl-3-carbethoxypyrrole-5-($\beta$-propionic Acid) (VII).**—Two hundred milligrams of the above anhydride and 60 mg. of freshly fused potassium acetate were dissolved in 25 ml. of acetic anhydride and refluxed three hours. After cooling, the solution was diluted with ether and extracted with water, dried over sodium sulfate and distilled to dryness. The remaining brownish crystalline mass was chromatographed over no. 2 Woelm alumina in 1:1 cyclohexane–benzene to give 125 mg. of needles (65%). Four recrystallizations from cyclohexane gave an analytical sample, m.p. 115–116°.

*Anal.* Calcd. for $C_{12}H_{15}O_3N$: C, 65.14; H, 6.83; N, 6.33. Found: C, 64.78; H, 6.98; N, 6.38.

The lactam was obtained by essentially the same procedure from the free acid in 47% yield. It was contaminated with a persistent yellow impurity.

**Ethyl 2,4-Dimethyl-3-carbethoxypyrrole-5-($\beta$-propionate) (XI).**—This ester was prepared by Fischer esterification of the corresponding acid VIII. One hundred milligrams of acid was dissolved in 15 ml. of absolute ethanol containing 3 drops of concentrated sulfuric acid, and the solution refluxed 2 hours. The usual working up gave needles which were rendered virtually colorless by two treatments with charcoal in ethanol at room temperature. The analytical sample was crystallized from cyclohexane and melted at 81.4–81.9°. The infrared spectrum displayed carbonyl absorption at 5.77 and 5.86 $\mu$, and N–H absorption at 2.78 $\mu$.

*Anal.* Calcd. for $C_{14}H_{21}O_4N$: C, 62.90; H, 7.92; N, 5.24. Found: C, 63.00; H, 8.02; N, 5.15.

**Ethyl *cis*-2,4-Dimethyl-3-carbethoxypyrrole-5-($\beta$-acrylate) (X).**—Thirty milligrams of the acrylic lactam was dissolved in 3 ml. of absolute ethanol and 2 ml. of 1 *M* sodium ethoxide in ethanol was added. The red-orange color faded rapidly, and after 1 minute the solution was acidified with sulfuric acid. The solution was evaporated to dryness and worked up with dichloromethane. The resulting pale yellow oil crystallized on trituration with aqueous ethanol. Two recrystallizations from this solvent gave 18 mg. (50%), m.p. 58–59°. The infrared spectrum showed carbonyl bands at 5.87 and 5.92 $\mu$, and N–H absorption at 3.08 $\mu$. There was no band in the 10.3–10.4 $\mu$ region.

*Anal.* Calcd. for $C_{14}H_{19}O_4N$: C, 63.38; H, 7.22; N, 5.28. Found: C, 63.04; H, 7.21; N, 5.24.

**Hydrogenation of Ethyl *cis*-2,4-Dimethyl-3-carbethoxypyrrole-5-($\beta$-acrylate) (X) to the Propionate XI.**—Fifteen milligrams of unsaturated ester was hydrogenated in 12 ml. of absolute ethanol containing 2 mg. of 10% palladium-on-charcoal at 25°. The usual working up gave needles, which after recrystallization from cyclohexane melted 80.8–81.7°; mixture melting point with authentic saturated ester (*vide supra*) 81.5–82.3°. The infrarred spectra of the two were superimposable.

**Ethyl 2,4-Dimethyl-3-carbethoxypyrrole-5-($\beta$-propionate) (XI) by Ethanolysis of the Corresponding Lactam.**—Thirty milligrams of saturated lactam was dissolved in absolute ethanol and treated with ethoxide just as the unsaturated lactam above. The ethyl ester was recovered in 97% yield. Recrystallization gave material identical with the authentic propionic ester.

**Determination of the Rates of Ethanolysis of the Lactams VI and VII.**—These rates were determined at 25° by following with a Beckman model DU ultraviolet spectrophotometer the change in absorption at a specific wave length as each lactam was opened to the corresponding ester in ethanolic ethoxide. Typical rate data, optical densities *versus* time, are reproduced in Table I.

TABLE I

| Typical data for unsatd. lactam VI | | Typical data for satd. lactam VII | |
|---|---|---|---|
| O.D. | *t*, min. | O.D. | *t*, min. |
| 0.050 | 0.3 | 0.371 | 0.3 |
| .088 | 0.7 | .349 | 0.7 |
| .108 | 0.9 | .331 | 1.0 |
| .125 | 1.1 | .300 | 1.6 |
| .142 | 1.3 | .290 | 1.8 |
| .164 | 1.6 | .276 | 2.1 |
| .177 | 1.8 | .268 | 2.3 |
| .204 | 2.2 | .250 | 2.7 |
| .244 | 3.0 | .255 | 2.9 |
| .275 | 3.8 | .231 | 3.2 |
| .310 | 5.0 | | |
| .325 | 5.8 | | |

1. **Unsaturated Lactam.**—The rate of development of the strong maximum at 346 m$\mu$ was measured. Eleven milligrams of lactam was dissolved in 50 ml. of absolute ethanol and diluted to 1/50 that strength. To 2 ml. of the resulting solution in a Beckman cell was added 0.5 ml. of 0.001 *M* sodium ethoxide solution.

2. **Saturated Lactam.**—The rate of decay of lactam absorption at 310 m$\mu$ was used in this case. Since the product ester shows very slight absorption at this wave length, it was necessary to use only the first few minutes readings of optical density, before appreciable concentration of product had developed, in determining the rate constant. Infinite-time optical density readings indicated that the *maximum* error introduced by this neglecting of small product concentrations is about 3.5% if only the first 3.2 minutes readings are employed.

Eleven milligrams of saturated lactam was dissolved in 50 ml. of absolute ethanol. This was diluted to 2/5 strength and 2 ml. used with 0.5 ml. of 0.001 *M* sodium ethoxide solution.

The following rate constants were calculated from each run made:

| | $k_{obs}$, min.$^{-1}$ |
|---|---|
| Ethanolysis of unsatd. | 0.324 |
| lactam VI | .307 |
| Ethanolysis of satd. | .169 |
| lactam VII | .166 |