The same compound was obtained in 80% yield by boiling (X) in DMF for 10 h. A mixed melting point of the carbazoles showed no depression.

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ACETALS OF LACTAMS AND ACID AMIDES.

61.* SYNTHESIS AND TRANSAMINATION OF INDOXYLS AND PYRROL-2-IN-4-ONES

S. Yu. Ryabova, Yu. I. Trofimkin, L. M. Alekseeva, G. A. Bogdanova, Yu. N. Sheinker, and V. G. Granik

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Reaction of N-acetylindoxyl and 2-methyl-3-ethoxycarbonylpyrrol-2-in-4-one with acetals of N,N-dimethylformamide and N-formylpiperidine has given the enaminoketones. Hydrolysis and transamination of these enaminoketones has been studied. The structures of the products were established by IR, PMR, and ^{13}C NMR spectroscopy.

A vigorously developing area of the chemistry of amide and lactam acetals is the study of their reactions with compounds with an active methylene group, and the heterocyclization of the resulting enamines [2-4]. In order to extend the range of uses of these reactions, it is necessary to use unconventional compounds containing the amide acetal groupings required for condensation. These include cyclic ketones, the enol forms of which are hydroxylated heteroaromatic systems. The aim of the present work was to examine the reactions of N-acetylindoxyl (I) and 2-methyl-3-ethoxycarbonylpyrrol-2-in-4-one (II) with N,N-DMF acetal (III) and N-formylpiperidine acetal (IV), and to examine the properties and reactions of the resulting enaminoketones, which are of interest as synthons for novel heterocyclization reactions.

Reaction of N-acetylindoxyl (I) with the acetal (III) in benzene was accompanied by side reactions, rendering isolation of the required enaminoketone [1-acetyl-2-dimethylaminomethyleneindolin-3-one (V)] extremely laborious [the isolated yield of (V) was ~20%]. Study of this reaction showed, however, that brief treatment of the reaction mixture with dilute HCl resulted in hydrolysis of the enaminoketone (V) to give 1-acetyl-2-formyl-3-hydroxyindole (VI), which was isolated in ~60% yield. In contrast to this, on reaction of the ketone (I) with the acetal (IV) there were no problems with the isolation of the product, and

*For Communication 60, see [1].

S. Ordzhonikze All-Union Research Institute for Pharmaceutical Chemistry, Moscow 119021.

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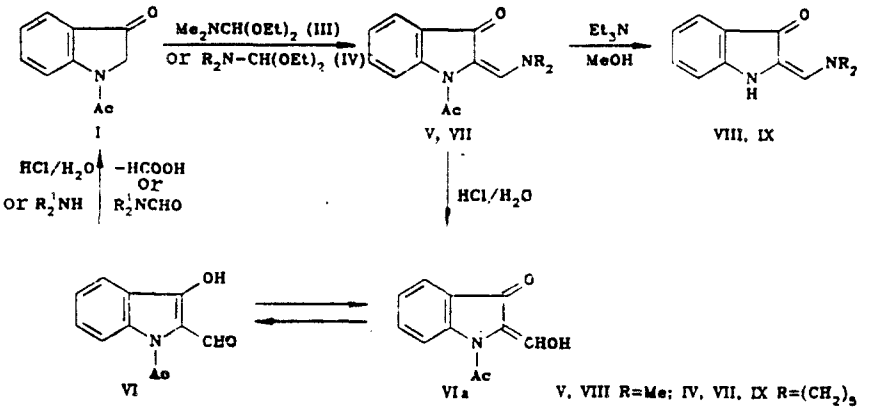
the enaminoketone (VII) was obtained in the pure state in satisfactory yields. This enaminoketone (VII) was, like (V), readily hydrolyzed by dilute HCl to the aldehyde (VI). It is interesting that the $C_{(2)}$–$C_{(2)}$I bond in the aldehyde is cleaved with great ease, so that when the time of treatment of this compound with dilute HCl is increased, or when it is treated with piperidine or aniline, N-acetylindoxyl (I) is obtained.

Rupture of the C–C bond in the aldehyde (VI) follows from nucleophilic attack by water on the 2-position of the indole ring (in acid solution), or by amines. In the first case, the reaction results in the formation of formic acid, which has been detected experimentally.* No N-deacetylation occurred. In order to obtain enaminoketones which do not contain an acetyl group, the reaction mixture from the condensation of the indoxyl (I) with the amide acetals (III) and (IV), without isolation of the enaminoketones (V) and (VII), was treated with triethylamine or piperidine in alcohol, to give 55 and 85% yields of 2-dimethylaminomethylene- and 2-piperidinomethylene-indolin-3-ones (VIII, IX). The structures of these compounds were confirmed by their IR and NMR spectra. For example, the IR spectra of the enaminoketones (see Experimental) showed strong absorption at 1660-1670 and 1600-1610 cm^{-1} characteristic of the enaminoketone grouping.

The PMR and ^{13}C NMR spectra of (V) and (VII-IX) also confirmed the presence of the enaminoketone moiety. Thus, in the ^{13}C NMR spectrum (DMSO-D_6) of (IX), signals for the methylene carbon, and for $C_{(2)}$ and $C_{(3)}$ were seen at δ 132.3, 113.5, and 181 ppm, respectively. In the PMR spectra of (VIII) and (IX), in addition to signals for the aromatic protons (6.80-7.50 ppm), signals were present for the methylene proton (~7.0 ppm), the dimethyl group in (VIII) (3.19 ppm), and the piperidine fragment in (IX) (1.62 and 3.55 ppm). The presence of an acetyl group at $N_{(1)}$ has a marked effect on the PMR spectra ($CDCl_3$) of (V) and (VII), the signals for the protons of the acetyl group and the enaminoketone fragment being considerably broadened. This type of signal could be due either to the presence of two amide conformers relative to the N–C bond of the acetyl substituent, or to relatively slow (on the NMR time scale) interconversion of the isomers with cis- and trans-disposed NR_2 and NAc groups.†

The PMR and ^{13}C NMR spectra ($CDCl_3$) of the hydrolysis product (VI) show, respectively, a signal for the CHO proton at ~10.0 ppm and one for the CHO carbon at 182.6 ppm (J_{CH} = 192.0 Hz), thus enabling this compound to be assigned with confidence the hydroxyaldehyde structure rather than the tautomeric hydroxymethylene ketone structure (VIa).



These enaminoketones can be used as starting compounds for the synthesis of various compounds. Specifically, one of the most characteristic reactions of compounds of this type is transamination. The enaminoketone (V) was reacted, without isolation in the pure state, with aromatic amines in acetic acid, to give satisfactory yields of the 1-acetyl-2-arylaminomethyleneindolin-3-ones (Xa-c). That these compounds possess the enaminoketone structure rather than the azomethine structure follows from examination of data previously reported [6, 7], according to which systems of this type possess the stable enaminoketone structure irrespective of substituents, temperature, and solvent. In addition, the IR spectra of (Xa-c) are very similar to those of (V) and (VII), which exist in the fixed enaminoketone form.

The presence of signals at ~182 ppm ($C_{(3)}$) in the ^{13}C NMR spectra (DMSO-D_6) of (Xa) and (XIIa) also support the enaminoketone structure for the transmination products.

In the PMR spectra (DMSO-D_6) of (Xa-c), the signals for the NH and methylene protons are seen as a broadened signal, or as two separate signals of equal intensity (the difference in the chemical shifts does not exceed 0.06 ppm) at 9.2-9.3 and 12.0 ppm, respectively. These types of signals for the protons of the enaminomethylene fragment appear to arise from the

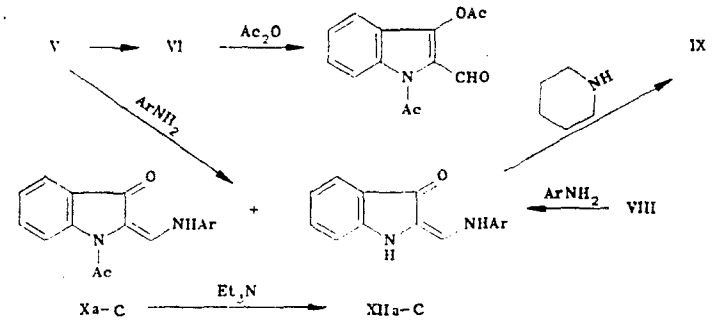
*The authors thank R. A. Dubinskii for the determination of formic acid in the reaction mixture, as described in [5].

†Data providing an answer to this question will be reported subsequently.

existence of two amide conformers relative to the C–N bond of the acetyl substituent. It should be emphasized that the chemical shifts of the NH protons indicate the presence of strong intramolecular hydrogen bonding, the existence of which is possible only for the enaminoketone form.

Another approach to the synthesis of the enaminoketones (Xa-c) is from the acetyl derivative of the hydroxyaldehyde (VI). Acetylation of the latter proceeds selectively at the hydroxyl group in the 3-position to give 1-acetyl-3-acetoxy-2-formylindole (XI), the structure of which follows from its IR spectrum [1670 (N–$COCH_3$), 1700 (CHO), and 1785 cm^{-1} ($OCOCH_3$)] and its PMR spectrum (acetone-D_6), which showed a signal for the aldehyde proton at 10.15 ppm and signals for the methyl groups of the N- and O-acetyl fragments at 2.45 and 2.78 ppm. Reaction of the acetoxyaldehyde (XI) with aromatic amines did not proceed cleanly. Chromatographic checks on the progress of the reaction of (XI) with aniline showed that, in addition to the starting aldehyde, the reaction mixture initially contained the enaminoketone (Xa), but after ~2 h a new product appeared.

Varying the proportions of the reactants and the temperature had no effect on the composition of the reaction mixture. Since the products differed in solubility, it was possible to separate them from the mixture, and the second product was found to be 2-anilinomethylene-indolin-3-one (XIIa), identical in its properties with the compound obtained previously [8] by reaction of indoxyl with orthoformic ester and aniline in acetic acid. Similarly, reaction of the aldehyde (XI) with p-anisidine also gives a mixture of the enaminoketones (Xb) and (XIIb). With p-chloroaniline, only (Xc) was isolated. All the N-deacetylated enaminoketones (XIIa-c) were also obtained by transamination of the enaminoketone (VIII) with aromatic amines. The best preparative method for these compound was, however, by N-deacetylating the enamines (Xa-c). We have used this method to synthesize the aminoketones (VIII) and (IX), and treatment of (Xa-c) with triethylamine in alcohol affords the required compounds (XIIa-c) in yields of ~90%.



It is noteworthy that the enaminoketones (XIIa-c) also undergo transamination. This was shown in the case of (XIIc), which on reaction with piperidine affords the piperidinomethyleneindolin-3-one (IX).

We have examined some of the properties of a cyclic ketone related to indoxyl, namely 2-methyl-3-ethoxycarbonylpyrrol-2-in-4-one (II). Reaction of this compound with the amide acetals (III) and (IV) takes place smoothly to give the enaminocarbonyl compounds (XIIa, b).* These compounds have similar IR spectra, with absorption for both carbonyl groups at 1690 (COOEt) and 1660 cm^{-1} (ketone CO), and for the NH group at 3140 cm^{-1}. The ^{13}C NMR spectrum (DMSO-D_6) of (XIIIa) showed signals for carbon atoms at 187.3, 136.5, and 112.1 ppm characteristic of the enaminoketone moiety, and attributed to $C_{(3)}$, the methylene carbon, and $C_{(2)}$, respectively. The PMR spectrum of (XIIIb) contained a signal for the vinyl proton at 7.13 ppm, i.e., at approximately the same field as the signal for the indoxyl analog (IX). Hydrolysis of the enaminoketone (XIIIa) did not give the hydroxyaldehyde, as reported above for the indoxyl analog (V), but instead the bis-compound (XIV). The IR spectrum of this compound showed absorption at 1690 and 1660 (COOEt and cyclic CO), 3240 (NH), and a broad band at ~3400 cm^{-1} which we attribute to the OH group.

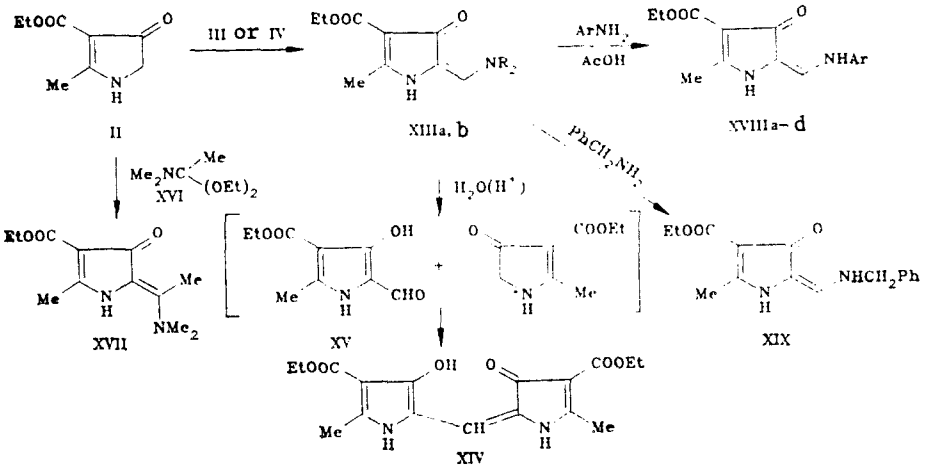
The mass spectrum showed a peak for the molecular ion with $M^{+\cdot}$ 348 and ion peaks 302 [M^+–C_2H_5OH] and 256 [M^+–$2C_2H_5OH$]. The latter peak was the strongest, and did not undergo further fragmentation to any great extent, indicating the presence of a conjugated system and the absence of substituents capable of being eliminated. The PMR spectrum (DMSO-D_6) of this compound showed a broadened triplet (δ 1.26 ppm), a quartet (δ 4.18 ppm), and a singlet (δ 6.80 ppm).†

*This compound can also be obtained from (XIIIa) by treatment with piperidine.

†The signals for the $C_{(2)}$ methyl groups overlap those for the solvent (DMSO-D_6). In view of its extremely low solubility, it was not possible to obtain the IR spectrum of (XIV) in solution, nor could the PMR spectrum in another solvent or the ^{13}C NMR spectrum be obtained.

These observations lead to the structure (XIV) for the compound obtained. It is apparently formed as follows. Hydrolysis of the enaminoketone (XIIIa) gives the aldehyde (XV), which then fragments to give formic acid [detected as described above for the hydrolysis of the enaminoketone (V)], followed by condensation of the aldehyde (XV) at the active methylene group of the starting 4-pyrrolinone (II) formed during this reaction. It is noteworthy that the CH_2 group in the latter compound is much more sterically accessible than in N-acetylindoxyl (I) as a result of the absence of the N-acetyl group. This is shown, for example, by the observation that the ketone (II), unlike (I), reacts readily with the more sterically hindered dimethylacetamide diethyl acetal (XVI) to give 2-methyl-3-ethoxycarbonyl-5-(N,N-dimethylamino)ethylidenepyrrol-2-in-4-one (XVII). The enaminoketones (XIIIa, b), like their indoline analog (VIII), react readily with aromatic amines. In this case, as with the indolinones, the presence of an acid (AcOH) is necessary to activate the enaminoketone moiety by preliminary protonation (probably O-protonation [9]), giving satisfactory yields of the arylaminomethyleneketones (XVIIIa-d). The IR spectra of these compounds showed absorption for COO (1660 and 1600 cm^{-1}) and NH (3140-3160 cm^{-1}).

In contrast to the reaction with aromatic amines, transamination of (XIIIa) with more basic amines such as benzylamine does not require acid catalysis, proceeding smoothly to give the benzylaminomethylene compound (XIX).



EXPERIMENTAL

IR spectra were obtained on a Perkin–Elmer-457 as pastes in Vaseline grease, and UV spectra on a Specord M-40 (Karl Zeiss, Jena) in ethanol. Mass spectra were obtained on a Varian MAT-112 mass spectrometer with direct sample introduction into the ion source, energy of ionizing electrons 70 eV, ionization chamber temperature 180°C. The PMR and ^{13}C NMR spectra of the compounds were recorded on a Varian XL-200, internal standard TMS. The reactions were followed and the purity of the compounds checked by TLC on Silufol UV-254 plates, with ethyl acetate (for V-XII) or 2-propanol–ammonia–ethyl acetate (3:1:5) (for XII-XIX), visualized in UV. The elemental analyses corresponded to the calculated values.

1-Acetyl-2-dimethylaminomethyleneindolin-3-one (V). To a suspension of 3.5 g (20 mmoles) of the indoxyl (I) in 40 ml of benzene was added 12 ml (~60 mmoles) of the acetal (III), and the mixture stirred for 1 h at 20°C. The resulting solution was boiled for 1 h, the benzene removed, and the residue extracted with boiling hexane (~300 ml) to extract the enaminoketone (V). The solid which separated on cooling was filtered off and washed with hexane to give 1 g (22%) of product, mp 101-102°C (from 2-propanol–hexane, 1:2). IR spectrum: 1725, 1660, 1600 cm^{-1}. $M^{+\cdot}$ 230.

1-Acetyl-2-piperidinomethyleneindolin-3-one (VII). To a suspension of 7 g (40 mmoles) of the indoxyl (I) in 80 ml of benzene was added 18.4 ml (88 mmoles) of the acetal (IV), and the mixture stirred for 1 h at 20°C. The resulting solution was boiled for 1 h, the benzene removed, and the (VII) (0.5 g) extracted as described above for (V). The residue was triturated with 2-propanol, and the resulting solid filtered off and washed with 2-propanol and ether to give 5.65 g of the enaminoketone (VII). Overall yield 6.15 g (57%), mp 130-131°C (from 2-propanol–hexane, 1:1). IR spectrum: 1685, 1660, 1600 cm^{-1}. $M^{+\cdot}$ 270.

1-Acetyl-2-formyl-3-hydroxyindole (VI). A. Obtained from 3.5 g (20 mmoles) of (I) as described for (V). After removal of the benzene, the residue was dissolved in ~150 ml of water and acidified to pH 2-3 with 3 ml of concentrated HCl. After 5 min,* the solid which had separated was filtered off and washed with water and 2-propanol to give 2.4 g (59%)

*After 1 h the solid was filtered off and washed with water and 2-propanol to give 51% of N-acetylindoxyl.

of product, mp 122-123°C (from 2-propanol). IR spectrum: 1700, 1620, 1580 cm^{-1}. UV spectrum, λ_{max} (log ε): 230 (4.22), 257 (4.03), 312 (3.95), 356 nm (3.89). PMR spectrum ($CDCl_3$): 10.24 (br.s, CHO), 2.79 (3H, s, $COCH_3$), 7.34-7.91 ppm (4H, m, arom. protons). $M^{+\cdot}$ 203.

B. To a suspension of 0.8 g (3 mmoles) of the enaminoketone (VII) in 10 ml of water was added with stirring 6 ml of 0.5 N HCl. After 3-5 min, a different solid separated from the solution obtained.* This was filtered off and washed with water, ethyl acetate, and ether to give 0.4 g (67%) of product. A mixed melting point with material obtained by method **A** showed no depression.

2-Dimethylaminomethyleneindolin-3-one (VIII) was obtained from 7 g (40 mmoles) of the idoxyl (I) and 24 ml (120 mmoles) of the acetal (III) in 80 ml of benzene, as described for (V) above. After removal of the benzene, the residue was dissolved in 60 ml of methanol, 6 ml of triethylamine added, and the mixture boiled for 30 min. The methanol was removed, the residue stirred with ethyl acetate, and the solid filtered off and washed with 2-propanol and ether to give 4.1 g (55%) of product, mp 215°C (decomp., from 2-propanol). IR spectrum: 3250-3100, 1675, 1615 cm^{-1}. UV spectrum, λ_{max} (log ε): 254 (4.05), 290 (4.03), 338 (4.32), 4.37 nm (4.12). PMR spectrum (DMSO-D_6); 7.01 (1H, s, CH), 6.78-7.31 (4H, m, arom. protons), 3.19 and 3.35 [6H, 2 s, $N(CH_3)_2$], 8.85 ppm (1H, s, NH). $M^{+\cdot}$ 188.

2-Piperidinomethyleneindolin-3-one (IX). A. From 7 g (40 mmoles) of the indoxyl (I) and 25 ml (120 mmoles) of the acetal (III) in 80 ml of benzene, 60 ml of methanol, and 10 ml of piperidine, as described above for the synthesis of (VIII) there was obtained the indolinone (IX), yield 8 g (88%), mp 260°C (decomp., from DMF). IR spectrum: 3200-3100, 1670, 1620 cm^{-1}. PMR spectrum (DMSO-D_6): 6.85 (1H, s, CH), 6.76-7.50 (4H, m, arom. protons), 1.62 (6H, m, β,γ-$3CH_2$), 3.55 (4H, t, α-$2CH_2$), 8.81 ppm (1H, s, NH). $M^{+\cdot}$ 228.

B. To a suspension of 3 g (10 mmoles) of the enaminoketone (Xc) in 150 ml of methanol was added 15 ml of piperidine, and the mixture heated with stirring to the boil. The resulting solution was boiled for 2 h, then the methanol was removed, the residue treated with ether, and the (IX) filtered off. Yield 1.8 g (82%).

C. Obtained from 5.14 g (19 mmoles) of the enaminoketone (XIIc), 250 ml of methanol, and 20 ml of piperidine, as in method **B**. Yield 3.25 g (75%). Mixed melting points with material obtained by methods **A** or **B** showed no depression.

1-Acetyl-2-formyl-3-acetylindoxyl (XI). A solution of 8 g (40 mmoles) of the hydroxyaldehyde (VI) in 80 ml of acetic anhydride was boiled for 10 min, cooled, and poured into 400 ml of water. After 2 h, the solid which had separated was filtered off and washed with water, 2-propanol, and ether to give 6.5 g (67%) of product, mp 111-113°C (from ethyl acetate). IR spectrum: 1785, 1700, 1670, 1610 cm^{-1}. PMR spectrum (acetone-D_6): 10.15 (1H, s, CH), 2.45 (3H, s, $OCOCH_3$), 2.48 (3H, s, $NCOCH_3$), 7.38-8.12 ppm (4H, m, arom. protons). $M^{+\cdot}$ 245.

1-Acetyl-2-phenylaminomethyleneindolin-3-one (Xa). A. Obtained from 3.5 g (20 mmoles) of the indoxyl (I) as described for (V). After removal of the benzene, the residue was treated with 25 ml of acetic acid and 1.9 ml (20 mmoles) of aniline. The mixture was stirred for 2 h at 20°C, then kept overnight. The acetic acid was evaporated, and the residue stirred with hot hexane, decanted, and triturated with 2-propanol. The solid obtained was filtered off and washed with 2-propanol and ether to give 2.2 g (39%) of product, mp 122-124°C (from acetonitrile). IR spectrum: 1670, 1650, 1600 cm^{-1}. UV spectrum, λ_{max} (log ε): 226 (4.02), 252 (4.20), 285 (4.04), 358 (4.33), 477 nm (4.36). $M^{+\cdot}$ 278.

B. To a solution of 1 g (4 mmoles) of the acetoxyaldehyde (XI) in 20 ml of benzene was added 0.75 ml (8 mmoles) of aniline, and the mixture stirred and kept at 20°C overnight. The enaminoketone (XIIa) (0.05 g) was filtered off, and the mother liquor evaporated. The residue was triturated with ether, and the solid filtered off and washed with ether. The yield of the enaminoketone (Xa) was 0.75 g (66%). A mixed melting point with material obtained by method **A** showed no depression.

1-Acetyl-2-(4'-methoxyphenyl)aminomethyleneindolin-3-one (Xb). A. Obtained as for (V), from 7 g (40 mmoles) of the indoxyl (I). After removal of the benzene, the residue was treated with 50 ml of acetic acid and 4.9 g (40 mmoles) of p-anisidine. The mixture was stirred for 2 h at 20°C, and kept overnight. It was then diluted with water and extracted with ether. The solid which then separated from the aqueous mother liquor was filtered off, and washed with water and 2-propanol. The ether extract was washed with water, the ether removed, and the residue triturated with a mixture of 2-propanol. The overall yield was 4 g (33%), mp 135-135.5°C (from 2-propanol). IR spectrum: 1670, 1640, 1600 cm^{-1}. $M^{+\cdot}$ 308.

*If the suspension was kept at 20°C for 24 h, N-acetylindoxyl was obtained in 40% yield.

B. From 1 g (4 mmoles) of the acetoxyaldehyde (XI) and 1 g (8 mmoles) of p-anisidine there were obtained as described for (Xa) (method **B**) 0.15 g of the enaminoketone (XIIb) and 0.8 g (64%) of the enaminoketone (Xb). A mixed melting point with material obtained by method **A** showed no depression.

1-Acetyl-2-(4'-chlorophenyl)aminomethyleneindolin-3-one (Xc). A. Obtained from 7 g (40 mmoles) of the indoxyl (I) as described for (V). After removal of the benzene, the residue was treated with 50 ml of acetic acid and 5.1 g (40 mmoles) of p-chloroaniline. After stirring for 2 h at 20°C, the mixture was kept overnight, and the solid which separated was filtered off and washed with acetic acid and ether. Yield 6.2 g (50%), mp 210-212°C (from DMF–methanol, 1:1). IR spectrum: 1675, 1650, 1610 cm^{-1}. $M^{+\cdot}$ 312.

B. Obtained from 0.25 g (1 mmole) of the acetoxyaldehyde (XI) and 0.26 g (2 mmoles) of p-chloroaniline in 5 ml of benzene as for (Xa) (method **B**). Yield 0.2 g (63%). A mixed melting point with material obtained by method **A** showed no depression.

2-Arylaminomethyleneindolin-3-ones (XIIIa-c). A. To a suspension of 0.56 g (3 mmoles) of the enaminoketone (VIII) in 10 ml of 2-propanol were added 3.2 mmoles of aniline, p-anisidine, or p-chloroaniline and 0.2 ml (3 mmoles) of acetic acid. The mixture was heated to the boil with stirring to give a solution, from which a different solid separated. The suspension was boiled for 15 min, cooled, and the solid filtered off and washed with 2-propanol and ether. Yield of (XIIa) 0.5 g (79%), mp 210-212°C (decomp. from DMF). IR spectrum: 3250-3100, 1690, 1605 cm^{-1}. UV spectrum: λ_{max} (log ε): 226 (4.02), 252 (4.00), 285 (4.04), 358 (4.33), 477 nm (4.36). $M^{+\cdot}$ 236. Yield of (XIIb) 0.73 g (91%), mp 250°C [decomp., from methanol–DMF (3:1)]. Yield of (XIIc) 0.65 g (80%), mp 295°C (decomp., from DMF). IR spectrum: 3300-3100, 1700, 1620, 1600 cm^{-1}. $M^{+\cdot}$ 270.

B. To a solution of 0.56 g (3 mmoles) of the enaminoketone (VIII) in 5 ml of acetic acid was added 0.3 g (3.2 mmoles) of aniline, and the mixture stirred and kept for 2 h at 20°C. The solid which separated was filtered off and washed with acetic acid and ether. Yield of (XIIa) 0.5 g (79%).

C. A mixture of 1.4 g (5 mmoles) of the enaminoketone (Xa), 14 ml of methanol, and 1.4 ml of triethylamine, or 6.45 ml (21 mmoles) of the enaminoketone (Xc), 200 ml of methanol, and 6.5 ml of triethylamine was boiled for 15 min. After cooling, the solid was filtered off and washed with methanol. Yield of (XIIa) 1 g (85%). Yield of (XIIc) 5.14 g (92%). A mixed melting point with material obtained by methods **A** or **B** showed no depression.

2-Methyl-3-ethoxycarbonyl-5-piperidinomethylenepyrrol-2-in-4-one (XIIIa). To a solution of 7 g (41 mmoles) of the hydroxypyrrole (II) in a mixture of 125 ml of absolute ethanol and 250 ml of DMF was added 18.3 g (124 mmoles) of the acetal (III), and the mixture stirred for 3 h at 20°C. After keeping overnight, the solid which had separated was filtered off and washed with DMF. Yield 6 g (65%), mp 228-230°C (from DMF). IR spectrum: 3140, 1690, 1660 cm^{-1}. UV spectrum, λ_{max} (log ε): 223 (4.20), 264 (4.25), 319 nm (4.51). $M^{+\cdot}$ 224.

2-Methyl-3-ethoxycarbonyl-5-piperidinomethylenepyrrol-2-in-4-one (XIIIb). A. Obtained from 4.6 g (27.2 mmoles) of the hydroxypyrrole (II) and 15.3 g (82 mmoles) of the acetal (IV) in a mixture of 50 ml of absolute ethanol and 120 ml of DMF as described for (XIIIa). Yield 4.1 g (56%), mp 213-215°C (benzene–methanol, 10:1). IR spectrum: 3140, 1690, 1660 cm^{-1}. PMR spectrum (CD_3OD): 7.13 (1H, s, CH), 1.32 (2H, q, CH_2CH_3), 4.20 (3H, t, CH_2CH_3), 2.50 (3H, s, CH_3), 3.59 (4H, t, α-CH_2), 1.73 ppm (6H, m, β,γ-3CH_2). $M^{+\cdot}$ 264.

B. To a solution of 0.65 g (2.2 mmoles) of the enaminoketone (XIIIa) in 65 ml of 2-propanol was added 0.65 ml (6.6 mmoles) of piperidine, and the mixture boiled for 12 h. After keeping overnight at 10°C, 0.1 g of the starting enaminoketone (XIIIa) was removed by filtration. The mother liquor was evaporated, and the residue crystallized from a mixture of benzene and methanol (10:1). Yield of (XIIIb) 0.15 g (26%). A mixed melting point with material obtained by method **A** showed no depression.

(2-Methyl-3-ethoxycarbonyl-4-hydroxypyrrol-5-yl)(2-methyl-3-ethoxycarbonyl-4-oxo-4,5-dihydropyrrol-5-yl)methene (XIV). A solution of 3 g (13 mmoles) of the enaminoketone (XIIIa) in 40 ml of 1 N HCl was boiled for 2 h, cooled, filtered, and the solid washed with water, alcohol, and ether. Yield 2.05 g (86%), mp 283-285°C (from DMF). IR spectrum: 3240, 1690, 1660 cm^{-1}. $M^{+\cdot}$ 348.

On boiling (XIIIa) or (XIIIb) in water for 1 h, (XIV) was obtained in yields of 40 and 30%, respectively.

2-Methyl-3-ethoxycarbonyl-5-(α-dimethylamino)ethylidenepyrrol-2-in-4-one (XVII) was obtained from 2.3 g (13.6 mmoles) of the pyrrolin-4-one (II) and 6.6 g (40.8 mmoles) of the acetal (XVI) in a mixture of 25 ml of absolute ethanol and 60 ml of DMF as described for (XIIIa). Yield 1.6 g (49%), mp 200°C (decomp., from benzene–ethanol, 4:1). IR spectrum: 3160, 1690, 1660 cm^{-1}.

2-Methyl-3-ethoxycarbonyl-5-arylaminomethylenepyrrol-2-in-4-ones (XVIIIa-d). A. To a suspension of 2.3 g (11 mmoles) of the enaminoketone (XIIIa) in 65 ml of 2-propanol were added 17 mmoles of the appropriate

arylamine and 0.85 g (14 mmoles) of acetic acid. The mixture was boiled for 16 h, cooled, and the solid filtered off and washed with water, 2-propanol, and ether to give 1.5 g (53%) of (XVIIIa), mp 218-220°C (from DMF). IR spectrum: 3140, 1690, 1670, 1600 cm^{-1}. UV spectrum, λ_{max} (log ε): 239 (4.23), 327 (4.15), 391 nm (4.44). $M^{+\cdot}$ 272.

Yield of (XVIIIb) 2.9 g (93%), mp 234-236°C (from DMF). IR spectrum: 3280, 3130, 1690, 1650 cm^{-1}.

Yield of (XVIIIc) 3.1 g (98%), mp 247-249°C (from DMF). IR spectrum: 3160, 1690, 1670, 1600 cm^{-1}.

Yield of (XVIIId) 1.65 g (51%), mp 273-275°C (from DMF). IR spectrum: 3140, 1680, 1590 cm^{-1}.

B. The enaminoketone (XIIIa) and the arylamine were stirred in acetic acid for 16 h, and the solid which separated was filtered off and washed with water, 2-propanol, and ether. The yields of (XVIIIa) and (XVIIIb) were 83 and 55%, respectively. Mixed melting points with the appropriate materials obtained by method A showed no depression.

2-Methyl-3-ethoxycarbonyl-5-benzylaminomethylenepyrrol-2-in-4-one (XIX). To a solution of 1.8 g (8 mmoles) of the enaminoketone (XIII) in 50 ml of 2-propanol was added 1.72 g (16 mmoles) of benzylamine. The mixture was boiled for 3 h, cooled, and the solid which separated was filtered off and washed with water, 2-propanol, and ether. Yield of (XIX) 1.65 g (71%), mp 216-218°C (from DMF). IR spectrum: 3140, 1700, 1680, 1660 cm^{-1}.

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