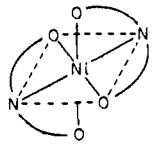
a complex of the salicylaldehyde–glycine Schiff base. The similarity of the spectra of these two complexes (in the copper reaction) constitutes additional evidence for structure III, and makes coordination through other functional groups of the vitamin (*e.g.*, the ring nitrogen) unlikely.

From the continuous variation study it may be concluded that two molecules of Schiff base are coördinated to each nickel ion. Two of the oxygen donors and the nitrogen donor of each molecule may be bound as shown in the following formulation



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BATON ROUGE, LA.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, CARNEGIE INSTITUTE OF TECHNOLOGY]

The Cyclization of Arylaminomethyl Styryl Ketones to 1-Aryl-5-phenyl-3-pyrrolidones

BY PHILIP L. SOUTHWICK AND HAROLD L. DIMOND[1]

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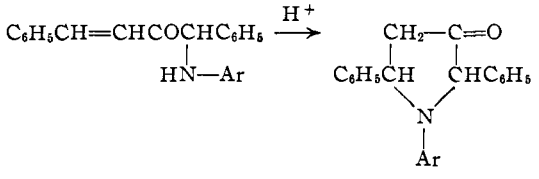
A series of five arylaminomethyl styryl ketones has been obtained by treatment of iodomethyl styryl ketone with aniline, *p*-chloroaniline, *p*-toluidine, *p*-anisidine and ethyl *p*-aminobenzoate. Four of the arylaminomethyl styryl ketones were cyclized to give 5-phenyl-3-pyrrolidones with the phenyl, *p*-chlorophenyl, *p*-tolyl or *p*-methoxyphenyl groups in the 1-position. 1,2-Diphenylpyrrolidine and 1,5-diphenyl-3-hydroxypyrrolidine have been obtained by reduction of 1,5-diphenyl-3-pyrrolidone. Anilinomethyl styryl ketone has been converted into the sodium salt of 1-anilino-4-phenyl-2-butanone-4-sulfonic acid by addition of sodium bisulfite.

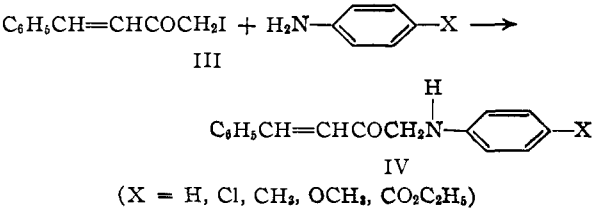
It has recently been shown[2] that 1-aryl-2,5-diphenyl-3-pyrrolidones (II) can be prepared by means of the acid-catalyzed cyclization of unsaturated arylamino ketones of the type described by formula I, compounds which can be obtained from benzyl styryl ketone by bromination with N-bro-



I II

mosuccinimide,[3] followed by treatment of the resulting 1,4-diphenyl-1-bromo-3-butene-2-one with aromatic amines.[2] By application to benzalacetone of a sequence of reactions similar to that applied to benzyl styryl ketone it was planned to prepare the less highly substituted 1-aryl-5-phenyl-3-pyrrolidones (V). To achieve this objective it was necessary to develop the new cyclization procedures to be described in the present paper.

The conversion of benzalacetone into iodomethyl styryl ketone (III) *via* 4-phenyl-1,3,4-tribromo-2-butanone already has been described.[3,4] Iodomethyl styryl ketone (III) reacts readily with aromatic primary amines to give the yellow, crystalline arylaminomethyl styryl ketones (IV). The amines used were aniline and four *para*-substituted anilines



III IV

(X = H, Cl, CH_3, OCH_3, $CO_2C_2H_5$)

p-chloroaniline, *p*-toluidine, *p*-anisidine and ethyl *p*-aminobenzoate. Ammonia and aliphatic primary amines reacted without yielding any well-defined products other than the hydroiodides of the amines used.

The cyclization of the arylaminomethyl styryl ketones (IV) to 1-aryl-5-phenyl-3-pyrrolidones (V) was not successfully accomplished by heating with 20% aqueous alcoholic sulfuric acid, a procedure which was highly successful with the amino ketones (I) derived from benzyl styryl ketone, for in place of the expected pyrrolidones dark tars were formed. Experiments with a variety of acids (acetic, hydrochloric, hydrobromic, sulfuric), using many variations in solvent, concentration of acid, time and reaction temperature, led either to extensive tar formation and, at best, only a trace of the cyclized product, or to recovery of unchanged starting material. Alkaline catalysis with sodium hydroxide also was ineffective. Heating the anilino ketone (IV, X = H) in boiling xylene did not produce ring closure. In one experiment the anisidino ketone (IV, X = OCH_3), when refluxed for 24 hours in neutral aqueous ethanol at a concentration of 1 g. in 20 ml. of solution, yielded enough of the corresponding pyrrolidone to permit purification of the product, but again an excessive amount of tar was formed and the purification was very difficult. It should be noted that in this case the tar did not

(1) Institute Fellow in Organic Chemistry, 1951–1953. This paper is based on the Ph.D. Thesis of Harold L. Dimond, Carnegie Insitute of Technology, March, 1953.

(2) P. L. Southwick, D. I. Sapper and L. A. Pursglove, THIS JOURNAL, **72**, 4940 (1950).

(3) P. L. Southwick, L. A. Pursglove and P. Numerof, *ibid.*, **72**, 1604 (1950).

(4) Bromination of benzalacetone with N-bromosuccinimide is not a successful method for preparation of bromomethyl styryl ketone, a compound which has yet to be reported. See P. L. Southwick, L. A. Pursglove and P. Numerof, *ibid.*, **72**, 1600 (1950).

come from the pyrrolidone after its formation, for these compounds are quite stable in boiling aqueous ethanol.

Two procedures finally were found whereby the arylaminomethyl styryl ketones (IV) could be cyclized to pyrrolidones much more successfully. The first of these to be discovered involved a period of heating in aqueous alcoholic solutions of sodium bisulfite. This cyclization procedure was tried on all of the compounds IV except the *p*-carbethoxyanilino derivative (X = $CO_2C_2H_5$) and yielded the desired product in every case, giving yields ranging from 22 to 60% and little or no tar. Simultaneously with cyclization to the 3-pyrrolidones, however, conjugate addition of sodium bisulfite (reaction 2) occurred to give the β-sulfonates VI. The cyclization most thoroughly studied was that of anilinomethyl styryl ketone (IV, X = H). It was shown in that case that the accompanying β-sulfonate (VI, X = H) is not converted into the 3-pyrrolidone under the conditions of the cyclization experiment either in the presence or absence of sodium bisulfite, and is therefore not an intermediate in pyrrolidone formation. The competing conjugate addition of sodium bisulfite places a limitation upon the yield of the pyrrolidones which is particularly severe in the case of 1-*p*-chlorophenyl-5-phenyl-3-pyrrolidone (22% yield).

The beneficial effect of sodium bisulfite is probably not to be attributed to the *p*H of its solutions, which are slightly acidic (*pK* for $HSO_3^- \rightleftarrows H^+ + SO_3^=$ in water at 25° is 7.20; *pK* for $H_2SO_3 \rightleftarrows H^+ + HSO_3^-$ is 1.76),[5] to its buffering action, or to its antioxidant effect. It was found that the use of monosodium phosphate, an acid salt with similar ionization constants (*pK* for $H_2PO_4^- \rightleftarrows H^+ + HPO_4^=$ is 7.21; *pK* for $H_3PO_4 \rightleftarrows H^+ + H_2PO_4^-$ is 2.12)[5] resulted in only a small yield of pyrrolidone accompanied by a large amount of tar. Likewise the formation of tar was not prevented by the use of the antioxidant hydroquinone in place of sodium bisulfite. These results suggested that sodium bisulfite might act in a more specific manner, possibly by maintaining the arylaminomethyl styryl ketones in the reaction solutions largely as the reversibly formed bisulfite addition compounds VII, reducing the concentration of the free ketones IV and thereby their tendency to form tars by intermolecular condensation reactions. It is possible that the adducts VII may to some extent undergo cyclization directly by means of an internal displacement reaction (reaction 4) as indicated in formula VII.[6]

(5) N. S. Lange, "Handbook of Chemistry," Seventh Edition, Handbook Publishers, Inc., Sandusky, Ohio, 1949, pp. 1407–1408.

(6) Similar indirect displacements have been observed in intermolecular reactions of allylic halides with amines and thiourea (S_N2' reactions). See W. G. Young, I. D. Webb and H. L. Goering, THIS JOURNAL, 73, 1076 (1951).

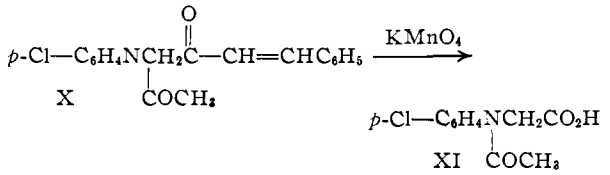
However, the observation that cyclization of the arylaminomethyl styryl ketones can occur in the absence of sodium bisulfite shows that the initially expected internal conjugate addition (reaction 3) almost certainly represents an important reaction path in these experiments. The cyclized intermediates VIII and IX would be transformed into the pyrrolidones V by proton transfers (reactions 5 and 6).

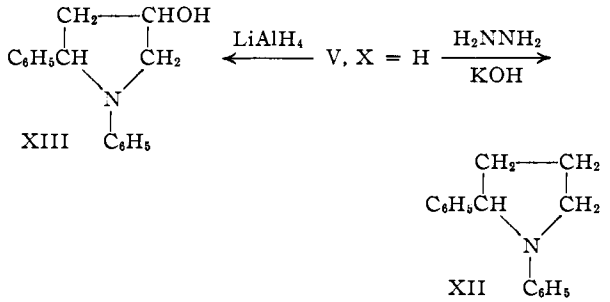
The belief that sodium bisulfite prevented tar formation by reducing the concentration of the free amino ketones IV in solution led to the discovery of a second successful cyclization procedure, in which the compounds were merely heated in refluxing aqueous ethanol at concentrations (0.8 g. in 210 ml. of solution) about one-tenth as great as had previously been used. Yields of the two pyrrolidones prepared in this way (V, X = Cl and OCH_3) were in the range 60–70% and little tar was formed. It therefore seems evident that this is an instance in which even the usually facile closure of a five-membered ring must be favored by rather high dilution in order to predominate over a competing intermolecular reaction.

The cyclization reactions of arylaminomethyl styryl ketones (IV) to 3-pyrrolidones (V) were accompanied by the predicted changes in the ultraviolet absorption spectra.[2] Thus, except in the case of the *p*-carbethoxyanilino derivative (IV, X = $CO_2C_2H_5$), in which two strong absorption bands evidently overlap to a large extent, the members of the former class of compounds all show a strong band near 293 mμ (see Table I) which is characteristic of β-phenyl-α,β-unsaturated ketones, as well as bands in the 243–253 mμ region due to the arylamine chromophore. After the cyclization reaction has occurred, the strong band at about 293 mμ is replaced by relatively weak absorption in that region, as it should be, because of the loss of the conjugation with the carbonyl group, and the spectra of the 3-pyrrolidones (Table II) show only

the chromophore of the aromatic amine moiety.

The structures assigned to the arylaminomethyl styryl ketones (IV) and the 3-pyrrolidones (V) were supported by chemical as well as spectral evidence. Oxidation of N-acetyl-*p*-chloroanilinomethyl styryl ketone (X) with potassium permanganate, for example, gave the expected N-acetyl-N-*p*-chlorophenylglycine (XI). The 3-pyrrolidones (V) displayed the chemical behavior expected of tertiary amines. Thus, whereas the arylaminomethyl styryl ketones (IV) are acetylated readily at the secondary amino group by ketene or acetyl chloride, the 3-pyrrolidones (V) do not react. Reduction of 1,5-diphenyl-3-pyrrolidone (V, X = H) by a modification of the Wolff–Kishner method yielded a tertiary amine which is evidently 1,2-diphenylpyrrolidine (XII). In other experiments the same pyrrolidone showed normal carbonyl reactivity in forming an oxime and a 2,4-dinitrophenylhydrazone, and in underoing reduction with lithium aluminum hydride to give a product which is evidently 1,5-diphenyl-3-hydroxypyrrolidine (XIII).





However, attempts to conduct addition reactions with phenylmagnesium bromide or phenyllithium led to intractable oily mixtures.

Whereas catalysis by strong acids was unsuccessful as a means of bringing about the ring-closure of the arylaminomethyl styryl ketones themselves, the 2,4-dinitrophenylhydrazone of anilinomethyl styryl ketone apparently undergoes an analogous ring closure with great ease in acid solution, and attempts to prepare it using the usual acidic reaction medium[7] led to the formation of the 2,4-dinitrophenylhydrazone of 1,5-diphenyl-3-pyrrolidone. The derivative of the uncyclized amino ketone has not been secured. The ultraviolet spectrum of the 2,4-dinitrophenylhydrazone shows the maximum at *ca.* 360 mμ (ε 23,200), characteristic of the derivative of a saturated ketone rather than the maximum at *ca.* 395 mμ characteristic of the derivative of a β-phenyl-α,β-unsaturated ketone.[8] Reaction of the keto group of the arylaminomethyl styryl ketones with a carbonyl reagent is not in itself sufficient to cause cyclization, since the oxime of anilinomethyl styryl ketone was prepared readily in pyridine solution. The ultraviolet absorption spectrum of this derivative gave clear indication (ε 24,000 for longest wave length maximum at 288 mμ) of retention of the conjugation, evidence for which is lacking in the spectrum of the oxime formed from 1,5-diphenyl-3-pyrrolidone, which shows maxima at 248 mμ, ε 12,300 and at 295 mμ, ε 2,910.

TABLE I

SPECTRA OF ARYLAMINOMETHYL STYRYL KETONES (IV)

Substituent group, X	Maxima λ	Maxima ε × 10⁻³	Minima λ	Minima ε × 10⁻³
H–	228	13.4	236	11.2
	243	12.8	258	7.4
	292	23.9		
Cl–	229	9.0	253	6.5
	253	15.1	266	11.1
	293	22.9		
CH_3–	227	15.1	235	12.2
	245	14.0	260	10.4
	293	24.9		
CH_3O–	228	14.4	235	12.0
	243	12.7	258	8.7
	292	23.9		
C_2H_5OC(=O)–	225	19.0	245	3.45
	305	42.5		

TABLE II

SPECTRA OF 1-ARYL-5-PHENYL-3-PYRROLIDONES (V)

Substituent group, X	Maxima λ	Maxima ε × 10⁻³	Minima λ	Minima ε × 10⁻³
H–	244	13.44	225	4.90
	291	3.55	272	2.82
Cl–	253	16.07	226	3.34
	295[a]	3.46		
CH_3–	246	14.75	226	6.05
	303	3.90	280	3.10
CH_3O–	244.5	13.29	225	6.14
	310	3.74	280	2.38

[a] Point of inflection.

Experimental[9,10]

4-Phenyl-1,3,4-tribromo-2-butanone.—This starting material for the preparation of iodomethyl styryl ketone was prepared more conveniently from benzalacetone directly than from benzalacetone dibromide, as previously described.[3] To a solution of 200 g. (1.37 moles) of benzalacetone in 1 l. of chloroform 440 g. (2.75 moles) of bromine was added dropwise with stirring while the mixture was cooled to maintain the temperature in the range 10–20°. The solution was allowed to stand for 3 hours in an ice-bath after the addition was complete. The tribromide which had precipitated was then removed by filtration, and the rest of the product was obtained by removing the solvent from the filtrate by evaporation under reduced pressure. Both portions of the tribromide were washed with small amounts of cold methanol to remove colored impurities and were then dried at room temperature. The product obtained in this way (388 g., 73.5% yield) melted at 114–117° and was satisfactory for conversion into iodomethyl styryl ketone as previously described.[3]

Preparation of Arylaminomethyl Styryl Ketones (IV).—In a typical run, approximately 5 g. (0.018 mole) of crystalline iodomethyl styryl ketone[3] was dissolved in 20 to 35 ml. of 95% ethanol by gently warming the mixture. To

(7) The procedure was that of R. L. Shriner and R. C. Fuson, "The Systematic Identification of Organic Compounds," Third Edition, John Wiley and Sons, Inc., New York, N. Y., 1948, p. 171.

(8) J. D. Roberts and C. Greene, THIS JOURNAL, 68, 214 (1946).

(9) Melting points are corrected.

(10) Microanalyses by Drs. G. Weiler and F. B. Strauss, Oxford, England; Micro Tech Laboratories, Skokie, Ill.; and Clark Microanalytical Laboratory, Urbana, Ill.

this solution the arylamine was added. In the case of aniline (4.3 g. used), *p*-toluidine (4.7 g. used) and *p*-anisidine (4.9 g. used) the molar ratio of amine to iodo ketone was roughly 2 or 2.5 to 1; in the case of *p*-chloroaniline (14.1 g. used) and ethyl *p*-aminobenzoate (18.2 g. used) the molar ratio was 6 to 1. Except in the case of aniline, the amines were dissolved in 95% ethanol, by warming if necessary, before they were added to the iodo ketone solution, 10 ml. of ethanol being used with *p*-toluidine and *p*-anisidine, 30 ml. with *p*-chloroaniline and ethyl *p*-aminobenzoate. The amino or amine solution was added rapidly to the solution of the iodo ketone and the reaction flask was cooled immediately in a stream of tap water for a period of 1 to 3 minutes while the walls of the flask were scratched with a glass stirring rod to promote crystallization of the product. In the case of the reaction with aniline, it was found beneficial to speed the cooling process by immersing the flask for brief periods in a Dry Ice–acetone mixture after the first cooling with tap water. The reaction mixtures were then allowed to stand in a refrigerator for 1 hour before the products were removed by filtration. The products were washed on the filter with cold 95% ethanol added in small portions until all dark-colored impurities were removed. Yields of crude products obtained in this way and data for individual arylaminomethyl styryl ketones are given below:

Anilinomethyl styryl ketone: yield 80%; yellow needles from 95% ethanol, m.p. 107–109° (bath preheated to 100°).

Anal. Calcd. for $C_{16}H_{15}ON$: C, 80.98; H, 6.37; N, 5.90. Found: C, 80.99; H, 6.37; N, 6.04.

***p*-Chloroanilinomethyl styryl ketone**: yield 81%; yellow plates (parallelograms) from 95% ethanol, m.p. 142–144.5°.

Anal. Calcd. for $C_{16}H_{14}ONCl$: C, 70.71; H, 5.19; N, 5.16. Found: C, 70.40; H, 5.05; N, 5.37.

***p*-Toluidinomethyl styryl ketone**: yield 75%; yellow needles from 95% ethanol, m.p. 103–105°.

Anal. Calcd. for $C_{17}H_{17}ON$: C, 81.23; H, 6.83; N, 5.57. Found: C, 81.25; H, 6.83; N, 5.49.

***p*-Anisidinomethyl styryl ketone**: yield 72%; orange-yellow needles from 95% ethanol, m.p. 114–115° (bath preheated to 105°).

Anal. Calcd. for $C_{17}H_{17}O_2N$: C, 76.38; H, 6.41; N, 5.24. Found: C, 76.20; H, 6.27; N, 5.37.

***p*-Carbethoxyanilinomethyl styryl ketone**: yield 49%; yellow plates from 95% ethanol, m.p. 153–155° (bath preheated to 140°).

Anal. Calcd. for $C_{19}H_{19}O_3N$: C, 73.79; H, 6.15; N, 4.53. Found: C, 74.07; H, 6.19; N, 4.34.

Preparation of 1-Aryl-5-phenyl-3-pyrrolidones. Procedure A.—To solutions of 1 or 2 g. of the arylaminomethyl styryl ketones (IV) in 20 to 50 ml. of 95% ethanol was added 1 or 2 ml. of a fresh solution of sodium bisulfite prepared by heating 8 g. (0.042 mole) of sodium metabisulfite with 20 ml. of water and 5 ml. of 95% ethanol. The resulting mixtures were refluxed for periods of 20 to 30 hours, then filtered to remove small quantities of suspended solids. The filtered solutions were evaporated to dryness under an air stream. The residues were triturated with 5 to 10 ml. of methanol, ethanol or water, and the resulting suspensions were filtered to remove the pyrrolidones, which were then purified by recrystallization.

Procedure B.—The arylaminomethyl styryl ketones IV (0.8 g.) were dissolved in boiling solutions prepared from 200 ml. of 95% ethanol and 10 ml. of water and the resulting mixtures were refluxed for 24 hours. The solvent mixtures had been refluxed for 30 minutes prior to the addition of the amino ketones in order to expel most of the air originally present in the solvents and in the flask. At the end of the reaction period the solvents were removed by distillation from a steam-bath and the residues, which crystallized during the distillation or when the flask was cooled, were recrystallized from ethanol. Data on individual pyrrolidones are given below:

1,5-Diphenyl-3-pyrrolidone: yields (procedure A) were 26 to 45% of crude product, m.p. 113–118°; gave tan plates from 95% ethanol, m.p. 119–121°.

Anal. Calcd. for $C_{16}H_{15}NO$: C, 80.98; H, 6.37; N, 5.90; mol. wt., 237. Found: C, 80.81; H, 6.16; N, 5.97; mol. wt. (Rast), 240.

1-*p*-Chlorophenyl-5-phenyl-3-pyrrolidone: yields were 22% (procedure A) and 69% (procedure B); obtained as white needles from methanol, m.p. 120–122°.

Anal. Calcd. for $C_{16}H_{14}NOCl$: C, 70.71; H, 5.19; N, 5.16. Found: C, 70.80; H, 4.93; N, 5.15.

1-*p*-Tolyl-5-phenyl-3-pyrrolidone: yield (procedure A) was 44% of a crude product, m.p. 121–124°; gave white crystals from methanol, m.p. 124–125°.

Anal. Calcd. for $C_{17}H_{17}NO$: C, 81.23; H, 6.83; N, 5.57. Found: C, 81.22; H, 6.79; N, 5.38.

1-*p*-Methoxyphenyl-5-phenyl-3-pyrrolidone: yields of crude material from procedure A ranged from 38 to 60%, a part of which was collected from the reaction mixture in the first filtration. Procedure B gave a 63% yield; obtained as white, silky needles from ethanol, m.p. 120–122°.

Anal. Calcd. for $C_{17}H_{17}NO_2$: C, 76.38; H, 6.41; N, 5.24. Found: C, 76.48; H, 6.47; N, 5.15.

Preparation of 1-Anilino-4-phenyl-2-butanone-4-sulfonic Acid and its Sodium Salt VI.—These compounds were obtained from reaction mixtures resulting from the preparation of 1,5-diphenyl-3-pyrrolidone by procedure A. After the residue obtained by evaporation of the reaction mixture was treated with methanol and the pyrrolidone had been removed by filtration, the methanol filtrate was evaporated to dryness. From a run starting with 2 g. of anilinomethyl styryl ketone this procedure gave a residue weighing 0.98 g. and melting over the range 143–165°. Recrystallization from 95% ethanol gave a compound melting at 200° when placed in a block preheated to 195°. This compound is a water-soluble sodium salt and appears to be the β-sulfonate (VI). It is not decomposed by sodium carbonate or hydrochloric acid solutions and is therefore evidently not a simple carbonyl bisulfite addition product. When the sample of the compound described above was dissolved in about 35 ml. of hot 95% ethanol and about 35 ml. of 10% hydrochloric acid was added, the free sulfonic acid was precipitated. No satisfactory method for simple recrystallization was found, but the acid was successfully purified by a procedure in which it was first dissolved in a small amount of hot 95% ethanol with the aid of a few drops of concentrated aqueous ammonia, and the resulting solution was filtered and then acidified to approximately *p*H 4 (as indicated by "Alk-acid"[11] test paper). The white crystalline precipitate which was formed melted at 196–196.5° when placed in a block preheated to 190°. Repetition of the purification procedure yielded a product of the same melting point. The compound gave a qualitative test for sulfur and corresponded in composition to a hemi-hydrate of the sulfonic acid corresponding to the sodium salt VI.

Anal. Calcd. for $C_{16}H_{17}O_4NS \cdot {}^1/_2H_2O$: C, 58.52; H, 5.83; N, 4.27. Found: C, 58.57; H, 5.88; N, 4.29.

Sodium β-sulfonates were formed in varying amounts from the other arylaminomethyl styryl ketones when treated with sodium bisulfite, as in procedure A. However, these compounds were not purified and characterized.

Acetylation of Arylaminomethyl Styryl Ketones.—Crystalline N-acetyl derivatives were obtained from the anilinomethyl, *p*-chloroanilinomethyl and *p*-toluidinomethyl styryl ketones. In the case of the first two amino ketones, acetylation was performed either with acetyl chloride (procedure A) or with ketene (procedure B). In the case of the *p*-toluidine derivative, only the ketene method was used.

Procedure A.—One gram of the arylaminomethyl styryl ketone was dissolved in 100 ml. of acetyl chloride and the mixture was refluxed for 30 to 60 minutes. The large excess of acetyl chloride was decomposed by the careful dropwise addition of water, and more water was added to precipitate the product from the resulting acetic acid solution. (The mixtures were diluted to volumes as large as 1 l.) After the mixture had been allowed to stand overnight, the product was removed by filtration, washed with water (and with cold ethanol in the case of the *p*-chloroanilino derivative) and purified by recrystallization.

Procedure B.—A stream of ketene gas was bubbled for 1 to 2 hours through solutions of 1 g. of the arylaminomethyl ketones in 15–25 ml. of chloroform. The solvent was evaporated with the aid of an air stream and the crude acetyl derivative was caused to separate in solid form by adding to the liquid or partially solidified residue either water (in the case of the anilino and *p*-chloroanilino derivatives) or ether and then petroleum ether (in the case of the *p*-toluidino derivative). Data on individual acetyl derivatives are given below.

(11) Fisher Scientific Company, Pittsburgh, Pa.

N-Acetylanilinomethyl styryl ketone: yields were 75% (procedure A) and 81% (procedure B). Obtained as short, light tan needles, m.p. 110.5–112°, from ethanol–water mixtures.

Anal. Calcd. for $C_{18}H_{17}O_2N$: N, 5.02. Found: N, 5.00.

N-Acetyl-*p*-chloroanilinomethyl styryl ketone: Yields were 92% (procedure A) and 96% (procedure B). Obtained as white crystals, m.p. 108–110° from ethanol.

Anal. Calcd. for $C_{18}H_{16}O_2NCl$: C, 68.89; H, 5.14. Found: C, 68.85; H, 5.44.

N-Acetyl-*p*-toluidinomethyl styryl ketone: yield was 85% (procedure B); obtained as white needles, m.p. 71–73°, from petroleum ether (b.p. 65–110°).

Anal. Calcd. for $C_{19}H_{19}O_2N$: C, 77.79; H, 6.53; N, 4.78. Found: C, 77.70; H, 6.52; N, 4.88.

1,2-Diphenylpyrrolidine Hydrochloride.—A mixture prepared from 1 g. of 1,5-diphenyl-3-pyrrolidone, 20 ml. of diethylene glycol and 20 ml. of 85% hydrazine hydrate was refluxed for 3.5 hours, and 4.29 g. of potassium hydroxide was then added.[12] At the end of an additional 3.5 hours at the reflux temperature the condenser was removed to allow escape of water vapor and permit the temperature to rise to 215°. The condenser was then replaced and refluxing was continued for 3 hours at the higher temperature. The mixture was cooled, diluted to 200 ml. with water, and extracted 3 times with 150-ml. portions of ether. The ether extracts were dried over magnesium sulfate and evaporated under an air stream. The oily residue was treated with 3 ml. of concentrated hydrochloric acid. The mixture was warmed and mixed thoroughly, then placed in a refrigerator overnight. The light-gray precipitate which separated was removed by filtration and washed on the filter with a few drops of acetone. The yield was 0.57 g. (52%) of a product melting at 96–112°, resolidifying at about 148° and finally melting again at 174–180°. The lower melting point may have been that of a hydrate. After several recrystallizations from acetone, white crystals were obtained, m.p. 180–182°.

Anal. Calcd. for $C_{16}H_{18}NCl$: C, 73.97; H, 6.98; N, 5.39. Found: C, 74.31; H, 7.04; N, 5.61.

The picrate of **1,2-diphenylpyrrolidine** was obtained by treating the pyrrolidine with picric acid in ethanol solution, using either the crude base as it was obtained directly from the reduction mixture or as obtained from the hydrochloride by treatment with alkali followed by ether extraction. Recrystallization from 95% ethanol gave bright yellow crystals, m.p. 130–131.5°.

Anal. Calcd. for $C_{22}H_{20}N_4$: C, 58.40; H, 4.46; N, 12.39. Found: C, 58.39; H, 4.79; N, 12.5.

1,5-Diphenyl-3-hydroxypyrrolidine (XIII).—A solution of 3 g. (0.011 mole) of 1,5-diphenyl-3-pyrrolidone in 200 ml. of tetrahydrofuran was added dropwise to a stirred solution of 1.5 g. (0.032 mole) of lithium aluminum hydride in 100 ml. of tetrahydrofuran. The mixture was stirred for 24 hours and allowed to stand at room temperature for 3 days. Excess hydride was decomposed by dropwise addition of 5 ml. of water, and the precipitate was removed by filtration. The filtrate was extracted 3 times with 100-ml. portions of 10% sodium hydroxide and dried over anhydrous magnesium sulfate. The precipitate mentioned above was added to the sodium hydroxide extracts and the mixture was extracted 3 times with 100-ml. portions of ether. The ether solutions were dried over magnesium sulfate, then were combined with the dried tetrahydrofuran solution and the resulting mixture was evaporated under a stream of air to leave a yellow oil. This oil was dissolved in hot petroleum ether (b.p. 65–110°). When the mixture cooled, the supernatant solution was decanted from a dark-colored gum which separated and placed in a refrigerator. During the course of several days, white crystals and some dark oil separated from the cold solution. The crystals (0.6 g., 20% yield) were separated mechanically from the oil and recrystallized from petroleum ether to give white needles or transparent cubes, m.p. 92.5–94°.

Anal. Calcd. for $C_{16}H_{17}ON$: C, 80.30; H, 7.16; N, 5.85. Found: C, 80.48; H, 7.54; N, 5.52.

1,5-Diphenyl-3-pyrrolidone 2,4-Dinitrophenylhydrazone.—The derivative was prepared from 0.5 g. of the pyrrolidone by use of the general procedure of Shriner and Fuson.[7] The yield was 0.9 g. (88%). The compound was recrystallized from mixtures of ethyl acetate and 95% ethanol. The needle-shaped crystals obtained varied considerably in color (from yellow to red) but melting points, mixed melting points and ultraviolet absorption spectra indicated that only one compound was present, m.p. 200° dec. when placed in a bath preheated to 180°.

Anal. Calcd. for $C_{22}H_{19}N_5O_4$: C, 63.30; H, 4.59; N, 16.78. Found: C, 63.29; H, 4.58; N, 16.5.

The same substance was obtained by conducting the reaction of 2,4-dinitrophenylhydrazine with anilinomethyl styryl ketone (IV, X = H) in the same way.

1,5-Diphenyl-3-pyrrolidone Oxime.—A 0.5-g. sample of 1,5-diphenyl-3-pyrrolidone was converted to the oxime by use of a general procedure described by Shriner and Fuson[13] in which pyridine and hydroxylamine hydrochloride are used. A yield of 0.23 g. (43%) of colorless or light amber needles or plates was obtained, m.p. 136–138° with sintering at 135°, following crystallization from an ethanol–water mixture.

Anal. Calcd. for $C_{16}H_{16}ON_2$: C, 76.16; H, 6.39; N, 11.10. Found: C, 75.76; H, 6.21; N, 10.8.

Anilinomethyl Styryl Ketone Oxime.—A 1-g. sample of the ketone was converted to the oxime by the same procedure mentioned above. A yield of 0.4 g. (38%) of the oxime was obtained. After several crystallizations from ethanol, tan plates were obtained, m.p. 160–163°.

Anal. Calcd. for $C_{16}H_{16}ON_2$: C, 76.16; H, 6.39; N, 11.10. Found: C, 76.11; H, 6.47; N, 11.0.

Potassium Permanganate Oxidation of N-Acetyl-*p*-chloroanilinomethyl Styryl Ketone.—One gram of N-acetyl-*p*-chloroanilinomethyl styryl ketone dissolved in 100 ml. of acetone was treated with a solution of 1.2 g. of potassium permanganate in 120 ml. of water. The stirred mixture was kept in an ice-bath during the reaction. After removal of manganese dioxide by filtration, the solution was evaporated to dryness under reduced pressure. The residue was dissolved in a small amount of water, and the solution was filtered and then acidified to precipitate the product. After recrystallization first from methanol and then from benzene, white crystals were obtained, m.p. 175–176°.

Anal. Calcd. for $C_{10}H_{10}O_3NCl$: C, 52.76; H, 4.43. Found: C, 52.95; H, 4.64.

The melting point of the product was not depressed by admixture with a sample of N-acetyl-N-*p*-chlorophenylglycine prepared from ethyl *p*-chloroanilinoacetate[14] by acetylation with acetic anhydride followed by saponification with alcoholic potassium hydroxide.

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(12) This procedure is a modification of that of Huang-Minlon, THIS JOURNAL, **68**, 2487 (1946).

(13) R. L. Shriner and R. C. Fuson, ref. 7, p. 202.

(14) W. Baker, W. D. Ollis and V. D. Poole, *J. Chem. Soc.*, 313 (1949).