

AMINOPHENANTHRENE DERIVATIVES PREPARED BY THE SCHMIDT REACTION¹

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A method commonly used for the preparation of aminophenanthrenes and aminotetrahydrophenanthrenes has been the Beckmann rearrangement of the oximes of the acetyl- or benzoyl-phenanthrenes and hydrolysis of the resulting amides (1, 2). This paper reports the use of the Schmidt reaction (3) as an improved method for converting ketones to amides in this series.

The most satisfactory procedure (4) consisted of treating the ketone with an excess of sodium azide for several hours in trichloroacetic acid at about 60°. This method gave yields of the amides markedly better than those usually obtained in the Beckmann rearrangement; this is presumed to be due at least in part to milder reaction conditions, which result in only a small amount of decomposition.

Since the yields recorded for the Beckmann rearrangements are in terms of the free amines, the amides formed in this study were hydrolyzed to the corresponding amines in order to make the data comparable. The hydrolysis gave almost theoretical yields in every case. The yields are reported in Table II, together with the yields which have been reported for the corresponding Beckmann conversion.

From unsymmetrical ketones it is theoretically possible to get two isomeric amides by either the Beckmann or the Schmidt reactions. Investigations of the Beckmann conversion of aryl methyl ketones has shown that the N-arylacetamide is the predominant product, with the N-methylaroylamide rarely being formed in more than traces. The results of this investigation, added to the few cases already reported (3), suggest that the same generalization is valid for the Schmidt reaction. No attempt, however, was made to determine the trace amounts of N-methylaroylamides in our products. The diaryl ketone 1-benzoylphenanthrene has been shown by Bachmann and Boatner (2) to give 82% of 1-phenanthranilide and 18% of benz-1-phenanthrylamide on oximation and rearrangement. When this ketone was subjected to the Schmidt reaction in trichloroacetic acid solvent with sulfuric acid as catalyst, nearly the same ratio of isomeric amides was obtained,⁴ as determined by the same methods which Bachmann and Boatner used to examine the mixed amides obtained by the Beckmann rearrangement. Our experiment with 1-benzoylphenanthrene provides a gratify-

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⁴ The results of a detailed investigation of the effect of structure on orientation in the Schmidt reaction by Smith and Horowitz will be reported elsewhere shortly.

ing demonstration of the role of acid strength in the formation of carbonium ions and the progress of the Schmidt reaction. A solution of 1-benzoylphenanthrene in trichloroacetic acid at 60° is yellow and does not react with hydrogen azide. The addition of an equivalent of sulfuric acid generated the intense blood-red color of the conjugate acid of 1-benzoylphenanthrene and immediately initiated a vigorous evolution of nitrogen. The more basic acetylphenanthrenes did not require the addition of sulfuric acid.

The suggestion of one of us (4) that the acid catalyst should not be stronger than necessary to carry out the Schmidt reaction at a convenient rate was checked by carrying out the reaction with various concentrations of sulfuric acid. 1-Acetonaphthone was treated with a standard amount of sulfuric acid of varying concentration (75% to 95%) and a fixed amount of sodium azide. The reaction products were hydrolyzed directly without purification in order to separate more easily the components, and the resulting 1-naphthylamine was isolated as the hydrochloride. The yields thus obtained are given in Table I. Analogous results were obtained from similar experiments on 2-acetonaphthone.

TABLE I
EFFECT ON YIELD OF VARIATION IN SULFURIC ACID STRENGTH

CONCENTRATION OF SULFURIC ACID	YIELD OF 1-NAPHTHYLAMINE HYDROCHLORIDE
75%	15%
85%	48%
90%	70%
95%	36%

Since any losses in the isolation procedure would be expected to be the same in all cases, the amount of final product should give an estimate of the efficiency of the original reaction. In general, the low yields with the more dilute acid were due to incomplete reaction, as shown by the large amounts of recovered ketone. The low yield with concentrated acid was due apparently to sulfonation, for the combined yields of recovered ketone and amine were far below 100%; no tetrazole formation was detected. Attempts to carry out Schmidt reactions in 95% sulfuric acid on 2- and 3-acetylphenanthrenes resulted in considerable nitrogen evolution, but the only result was incomplete recovery of impure starting material.

EXPERIMENTAL

1-Acetonaphthalide from 1-acetonaphthone. Effect of various concentrations of sulfuric acid. Since all the following reactions were run under as nearly identical conditions as possible, only the experiment with 90% sulfuric acid will be described. To an ice-cold mixture of 3.4 g. (0.02 mole) of 1-acetonaphthone and 20 ml. of 90% sulfuric acid was added 2.0 g. (0.03 mole) of powdered sodium azide (Eastman Kodak Co. Technical). Any lumps were broken up with a stirring rod and the mixture was kept at 0° to 5° with occasional stirring for eight hours. Nitrogen evolution was vigorous at the start of the reaction, but was inappreciable after six hours. The mixture was poured with stirring on ice and made basic with sodium

hydroxide. Evaporation of the benzene extracts gave a brown, pasty solid which was dissolved in a solution of 100 ml. of hot alcohol and 5 ml. of hydrochloric acid. After refluxing for twenty-four hours the solvent was evaporated, and the residue was made basic with 10% sodium hydroxide and extracted with benzene. The benzene layer was dried over sodium sulfate and treated with dry hydrogen chloride. The precipitated 1-naphthylamine hydro-

TABLE II
YIELDS AND PRODUCTS OF SOME SCHMIDT REACTIONS USING TRICHLOROACETIC ACID

SUBSTITUTED PHENANTHRENE	PRODUCT PHENANTHRENE	YIELD %	M. P. °C FOUND	M. P. °C REPORTED	YIELD BY BECK-MANN CONVERSION %
7-Acetyl-9-methyl-1,2,3,4-tetrahydro- (5)	7-Amino-9-methyl-1,2,3,4-tetrahydro-	93	98-99	98.5-99.5 (1)	59 (1)
7-Acetyl-9-ethyl-1,2,3,4-tetrahydro- ^a	7-Acetamido-9-ethyl-1,2,3,4-tetrahydro-	99	188-190 ^b		
9-Acetyl-2-methyl-1,2,3,4-tetrahydro- (6)	9-Amino-2-methyl-1,2,3,4-tetrahydro-	81	89-91	90-91	70 (6)
9-Acetyl-4-methyl-1,2,3,4-tetrahydro-	9-Amino-4-methyl-1,2,3,4-tetrahydro-	82	200-202 dec.	203-205 dec. (1) ^c	68 (1)
2-Acetyl- ^a	2-Amino-	88	82-84	85 (7)	79 (2)
3-Acetyl- ^a	3-Amino-	80	85-86	87.5 (7)	85 (2)
9-Acetyl- (2)	9-Amino-	73	135-137	137-138 (8)	48 (2)
1-Benzoyl- ^a	1-Benzamido- and 1-phenanthranilide	93-100	205-213		87 (2)

^a Kindly supplied by Dr. W. E. Bachmann.

^b A sample recrystallized for analysis melted at 193-194°: *Anal.* Calc'd for C₁₈H₂₁NO: C, 80.1; H, 7.86. Found: C, 80.2; H, 7.52. Analysis by Micro-Tech Laboratories, Skokie, Illinois.

^c The picrate was used as a derivative, since the free amine is unstable.

chloride weighed 2.5 g. (70% over-all yield). A sample of 1-naphthylamine prepared from the hydrochloride melted at 48-50°.

Schmidt reaction using trichloroacetic acid as solvent. The following method was used with minor variations in all of the experiments. Yields and other pertinent data are given in Table II. In all cases the yield is calculated without correction for recovered starting material. To a solution of 0.02 mole of acetylphenanthrene or acetyltetrahydrophenan-

threne in 25 to 30 g. of trichloroacetic acid at 60° was added 2.0 g. (0.03 mole) of powdered sodium azide all at once. Any lumps were broken up with a stirring rod and the solution was maintained with occasional stirring at 60° for six to eight hours; in some cases a further small amount of sodium azide was added after three or four hours. The mixture was poured on 100 g. of ice. If the precipitated material was crystalline it was filtered, washed well with water, and dried. After one crystallization from alcohol it was usually pure enough for identification. If the reaction product was oily, it was extracted with benzene. The benzene layer was washed with 10% hydrochloric acid, 10% sodium hydroxide, and water. After being dried with sodium sulfate, the benzene was removed in a current of air and the residue was triturated with petroleum ether (60-70°) and if necessary, crystallized from alcohol. In several cases starting material could be recovered from the petroleum-ether wash. Hydrolysis of the amides was carried out following the method of Bachmann and Boatner (2) using alcoholic hydrochloric acid. The yield of the amines obtained by the hydrolysis of the amides varied from 96 to 100%. The over-all yields of the various amines are given in Table II.

Schmidt reaction on 1-benzoylphenanthrene. A solution of 1.0 g. of 1-benzoylphenanthrene in 15 g. of molten trichloroacetic acid was treated with 1.0 ml. of conc'd sulfuric acid and 0.3 g. of sodium azide at about 60°; two more portions of 0.1 g. each of sodium azide were added twenty minutes and thirty minutes from the start, respectively. One hour and thirty minutes from the start, the mixture was poured into ca. 100 ml. of cold water and the precipitated tan solid was collected and washed well with water; wt. in different runs 0.97-1.06 g. (93-100%), m.p. 205-213°. Part of the crude mixed amides was recrystallized twice from acetone, yielding 26% of nearly pure 1-phenanthranilide, m.p. 245-247°. This is essentially the same as the experience of Bachmann and Boatner (2) with the mixed amides from the Beckmann rearrangement. Another portion (0.32 g.) was refluxed with alcoholic hydrochloric acid for 19 days; there was obtained 0.03 g. (15%) of 1-phenanthrylamine, m.p. 143-145°, and 0.23 g. (72%) of 1-phenanthranilide, m.p. 249-250° after decolorizing with charcoal in acetone. Bachmann and Boatner, working on a much larger scale but with otherwise similar conditions, obtained 18% of 1-phenanthrylamine and 82% of 1-phenanthranilide of unspecified purity.

Hydrolysis of 0.97 g. of crude mixed amides with 25 ml. of glacial acetic acid and 5 ml. of conc'd hydrochloric acid in a sealed tube at 160-220° for 10 hrs. yielded 0.15 g. (23%) of crude 1-phenanthrylamine, identified by conversion to its picrate, m.p. 203-204° in 95% yield; 0.32 g. (44%) of 1-phenanthroic acid, m.p. 228-232°, and some impure neutral material presumed to be unhydrolyzed 1-phenanthranilide. Bachmann and Boatner report 1-phenanthrylamine picrate to melt at 203-204°, and 1-acetamidophenanthrene to melt at 218.5-219.5°. We obtained the m.p. 203-204° for the picrate of the reaction product as ordinarily collected. However, if a small first crop (m.p. 203-204°) was taken, and the remainder collected as a large second crop; the m.p. was 215-216°. Both crops of picrate gave 1-acetamidophenanthrene, m.p. 223.5-224.5° separately and when mixed with each other, in high yield; and when samples of picrate from each melting range were mixed an intermediate m.p. was obtained. All these results were reproducible. Bachmann and Boatner obtained 14% of 1-phenanthrylamine and 63% of 1-phenanthroic acid from a similar hydrolysis of the mixed amides from the Beckmann rearrangement.

SUMMARY

The use of the Schmidt reaction as a superior method for the preparation of naphthyl- and phenanthryl-amines is described. In this series of compounds this method gives better yields and is simpler to carry out than the usual Beckmann rearrangement. A study was made of the effect of certain experimental conditions on the yield of the reaction.

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