[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF CALIFORNIA AT SANTA BARBARA]

Reactions of Aromatic Amines with Aliphatic Ortho Esters. A Convenient Synthesis of Alkyl *N*-Arylimidic Esters

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Heating equimolar mixtures of ethyl orthoacetate and aromatic primary amines results in formation of the corresponding ethyl *N*-arylacetamidates in high yields. This synthesis of *N*-arylacetimidic esters differs from the analogous synthesis of *N*-arylformimidic esters in two ways: *N,N'*-diarylamidines are not formed as intermediates, and acid catalysts need not be added to the reaction mixtures. Direct formation of *N*-arylimidic esters also occurs when ethyl orthopropionate reacts with aniline, and when a sterically-hindered aromatic primary amine reacts with ethyl orthoformate. *N*-Arylacetimidic esters react only very slowly with aromatic primary amines, even at high temperatures in the presence of acid catalysts. However, under the proper conditions this reaction affords satisfactory yields of *N,N'*-diarylacetamidines. The mechanisms of these reactions are discussed briefly.

Aromatic primary amines react with ethyl orthoformate to form *N,N'*-diarylformamidines in excellent yields.[1-3] The resulting formamidines react slowly with a second mole of ethyl orthoformate, in the presence of acid catalysts, to yield ethyl *N*-arylformimidates.[4,5] Roberts and De Wolfe[5] showed that these transformations are the result of consecutive, reversible reactions 1 and 2:

$$ArNH_2 + RC(OC_2H_5)_3 \rightleftharpoons ArN{=}CROC_2H_5 + 2\ C_2H_5OH \quad (1)$$

$$ArN{=}CROC_2H_5 + ArNH_2 \rightleftharpoons ArN{=}CR{-}NHAr + C_2H_5OH \quad (2)$$

When R = H, reaction 2 forward is much faster than reaction 1 forward. Consequently, as long as an appreciable amount of aromatic amine is present in the reaction mixture, it reacts rapidly with the initially formed formimidic ester to yield the diarylformamidine. The net result is the sum of equations 1 and 2 (Equation 3, R = H):

$$2\ ArNH_2 + RC(OC_2H_5)_3 \longrightarrow ArN{=}CR{-}NHAr + 3\ C_2H_5OH \quad (3)$$

Recently we attempted to prepare a series of *N,N'*-diarylacetamidines by using reaction 3, R = CH_3. To our surprise, reaction conditions which result in high yields of diarylformamidines from ethyl orthoformate gave poor yields of diarylacetamidines from ethyl orthoacetate. Ethyl *N*-arylacetimidates and unchanged aromatic amines were the major products obtained.

This observation indicated that, in reactions of aromatic primary amines with ethyl orthoacetate, reaction 2 (R = CH_3) is very much slower than reaction 1 (R = CH_3), and suggested that heating equimolar amounts of ethyl orthoacetate and an aromatic primary amine together should afford a convenient method of synthesizing the corresponding ethyl *N*-arylacetimidate. This turned out to be the case. When a number of aromatic primary amines was allowed to react with ethyl orthoacetate, excellent yields of *N*-arylacetimidic esters were obtained. The reaction proceeds smoothly at reflux temperatures and, unlike the analogous synthesis of *N*-arylformimidates,[4] no acid catalyst need be added to the reaction mixture.

The synthesis of *N*-arylacetimidic esters reported here is an extension of Roberts' method of preparing *N*-arylformimidic esters.[4] However, unlike Roberts' reaction, this synthesis proceeds rapidly and smoothly in the absence of added acid catalysts, and diarylamidines are not formed as intermediates. In fact, when diphenylacetamidine was refluxed with ethyl orthoacetate for twenty-two hours in the presence of *p*-toluenesulfonic acid–conditions similar to those used by Roberts in preparing *N*-arylformimidic esters—extensive decomposition of the orthoester occurred, but little or no imidic ester was formed. The diphenylacetamidine was recovered unchanged.

The synthetic method described here is probably general for the preparation of *N*-arylimidic esters other than *N*-arylformimidic esters; for example, ethyl *N*-phenylpropionimidate was obtained in high yield from aniline and ethyl orthopropionate. In the case of a highly hindered aromatic primary amine, the reaction also worked with ethyl orthoformate. When 2,6-diethylaniline was heated with an equivalent amount of ethyl orthoformate, *without the addition of an acid catalyst*, a 90% yield of ethyl *N*-(2,6-diethylphenyl)formimidate was obtained; no *N,N'*-bis(2,6-diethylphenyl)formamidine was isolated. Apparently, sterically hindered *N*-arylformimidic esters do not react rapidly with hindered arylamines to form *N,N'*-diarylformamidines.

Only three ethyl *N*-arylacetimidates (ethyl *N*-

(1) L. Claisen, *Ann.*, **287**, 362 (1895).
(2) R. Walther, *J. prakt. Chem.*, [2] **52**, 429 (1895).
(3) F. B. Dains and E. W. Brown, *J. Am. Chem. Soc.*, **31**, 1148 (1909).
(4) R. M. Roberts, *J. Am. Chem. Soc.*, **71**, 3848 (1949).
(5) R. M. Roberts and R. H. DeWolfe, *J. Am. Chem. Soc.*, **76**, 2411 (1954).

phenylacetimidate,[6] ethyl *N*-*o*-tolylacetimidate,[7] and ethyl *N*-*p*-tolylacetimidate[7]) are described in the literature. Lander[6,7] prepared all of these esters by alkylation of the silver salts of the corresponding *N*-arylacetamides. Arens and Rix[8] prepared ethyl *N*-phenylacetimidate by the reaction of aniline with ethoxyacetylene. They state that ethyl orthoacetate may be substituted for ethoxyacetylene, but give no experimental details. Ethyl *N*-phenylacetimidate has also been prepared from aniline and ketene acetal.[9] Ethyl *N*-phenylpropionimidate was recently prepared by Nieuwenhuis and Arens[10] from aniline and 1-ethoxypropyne.

With the exception of the brief report of Arens and Rix,[8] the present work appears to be the first description of the preparation of *N*-arylacetimidic or propionimidic esters from aromatic amines and the aliphatic ortho esters. Compounds similar in structure to acetimidic esters have been prepared by the reaction of ethyl orthoacetate with thiosemicarbazide[11] and with alkylureas.[12]

In order to determine whether our initial failure to obtain satisfactory yields of diarylacetamidines was due to a very slow rate for reaction 2 forward (R = CH_3), or to an unfavorable equilibrium constant for reaction 2 (R = CH_3), ethyl *N*-arylacetimidates were heated with equimolar amounts of the corresponding aromatic amines. These experiments showed that *N,N'*-diarylacetamidines can be prepared in high yields using reaction 2, but that the reaction is very slow at 140°, even when *p*-toluenesulfonic acid is present as a catalyst. The slow rate of this reaction is in striking contrast to the ease with which *N*-arylformimidates react with aromatic amines (reaction 2, R = H). Roberts[13,14] found that the formimidic esters react very rapidly with arylamines in the presence of traces of acids, even at room temperature.

When a mixture of equimolar amounts of aniline and ethyl *N*-phenylacetimidate containing a trace *p*-toluenesulfonic acid was heated for four minutes at 140°, only about 2% of the theoretical yield of *N,N'*-diphenylacetamidine was obtained. Heating a similar mixture for three and one-half hours at 140° gave a 25% yield of the amidine, while heating for twenty-two hours at 140° resulted in a 56% yield of the amidine. A plot of $1/C$ *vs.* time (C = concentration of unchanged aniline or ethyl *N*-phenylacetimidate) for these three experiments is nearly linear, with a slope of 1.4×10^{-5} l./mole sec. This indicates that heating the reaction mixture for a sufficiently long time should result in a high yield of diphenylacetamidine. In support of this prediction, prolonged heating of a reaction mixture consisting initially of 0.4 mole of aniline and 0.2 mole of ethyl orthoacetate plus a trace of *p*-toluenesulfonic acid yielded 72% of the theoretical amount of crude *N,N'*-diphenylacetamidine. The overall yield of recrystallized amidine was 63%. The only other substances identified in the reaction mixture were ethanol, aniline, and ethyl *N*-phenylacetimidate.

Electron-withdrawing aryl substituents retard reaction 2, while electron-releasing substituents facilitate it. Heating an equimolar mixture of *m*-chloroaniline and ethyl *N*-*m*-chlorophenylacetimidate containing a trace of *p*-toluenesulfonic acid for three and one-half hours at 140° caused a 20% conversion of the reactants into *N,N'*-di-*m*-chlorophenylacetamidine, while a similar mixture of *p*-ethoxyaniline and ethyl *N*-*p*-ethoxyphenylacetimidate, heated for the same length of time under the same conditions, gave a 55% yield of *N,N'*-di-*p*-ethoxyphenylacetamidine.

The occurrence of reaction 2 reverse (R = CH_3), the alcoholysis of *N,N'*-diphenylacetamidine, was demonstrated by refluxing the amidine with absolute ethanol in the presence of *p*-toluenesulfonic acid. The reaction is quite slow, but a small quantity of an approximately equimolar mixture of aniline and ethyl *N*-phenylacetimidate was isolated and identified by infrared spectrophotometry.

EXPERIMENTAL

Reagents. Aromatic primary amines from commercial suppliers were redistilled or recrystallized before use. Ethyl orthoformate, ethyl orthoacetate, and ethyl orthopropionate, obtained from Eastman Kodak Co. or from Kay-Fries Chemicals, Inc., were redistilled before use.

N-Arylacetimidic esters. The aromatic amine (0.25 mole) and 0.28 mole of triethyl orthoacetate were heated in a 200 ml. Claisen flask fitted with a 20-cm. Vigreux column. (A slight excess of the ortho ester was used, since it is easier to separate unchanged ortho ester from the reaction product than unchanged amine, due to the greater difference in boiling points.) Ethanol was distilled as rapidly as it formed, until almost the theoretical quantity (0.50 mole) was collected. The reaction mixture was cooled, and distillation resumed at reduced pressure. After collecting a forerun of ethyl orthoacetate and a small intermediate fraction, the ethyl *N*-arylacetimidic ester was obtained. In most cases very little residue remained in the still pot. Yields are calculated from the weight of product obtained in this distillation, and are based on the amount of amine used.

The imidic ester fraction was then carefully redistilled at reduced pressure, a center cut being saved for determination of physical properties and for elementary analysis.

The reaction appears to be applicable to any aromatic primary amine, and yields in most cases are better than 85%. Properties of the individual *N*-arylacetimidic esters are reported below.

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(8) J. F. Arens and T. R. Rix, *Koninkl. Ned. Akad. Wissenschap., Proc.*, **57B**, 275 (1954).
(9) H. M. Barnes, D. Kundiger, and S. M. McElvain, *J. Am. Chem. Soc.*, **62**, 1281 (1940).
(10) J. Nieuwenhuis and J. F. Arens, *Rec. trav. chim.*, **77**, 761 (1958).
(11) C. Ainsworth, *J. Am. Chem. Soc.*, **78**, 1973 (1956).
(12) C. W. Whitehead and J. J. Traverso, *J. Am. Chem. Soc.*, **77**, 5872 (1955).
(13) R. M. Roberts, *J. Am. Chem. Soc.*, **72**, 3603 (1950).
(14) R. M. Roberts, R. H. DeWolfe, and J. H. Ross, *J. Am. Chem. Soc.*, **73**, 2277 (1951).

Ethyl N-phenylacetimidate. Yield, 74%; b.p. 94.5° at 12.5 mm., n_D^{25} 1.5167, d_4^{25} 0.986 (lit. b.p. 93–94° at 9 mm.[9]); MR(calcd.) 50.26,[15] MR(obs.) 50.06.

Ethyl N-o-tolylacetimidate. Yield, 94%; b.p. 104–105° at 13.0 mm., n_D^{25} 1.5121, d_4^{25} 0.968 (lit. b.p. 125–130° at 20 mm.[7]); MR(calcd.) 54.88, MR(obs.) 54.95.

Ethyl N-m-tolylacetimidate. Yield, 87%; b.p. 116–117° at 11.3 mm., n_D^{25} 1.5147, d_4^{25} 0.968; MR(calcd.) 54.88, MR(obs.) 55.19.

Anal. Calcd. for $C_{11}H_{15}NO$: C, 74.53; H, 8.15. Found: C, 75.20; H, 8.51.[16]

Ethyl N-p-tolylacetimidate. Yield, 87%; b.p. 111–112° at 13.3 mm., n_D^{25} 1.5151, d_4^{25} 0.977 (lit. b.p. 125–130° at 12 mm.[7]); MR(calcd.) 54.88, MR(obs.) 54.71.

Ethyl N-o-chlorophenylacetimidate. Yield, 77%; b.p. 119–120° at 16.2 mm., n_D^{25} 1.5289, d_4^{25} 1.105; MR(calcd.) 55.13, MR(obs.) 55.16.

Ethyl N-m-chlorophenylacetimidate. Yield, 90%; b.p. 121–123° at 12.9 mm., n_D^{25} 1.5318, d_4^{25} 1.101: MR(calcd.) 55.13, MR(obs.) 55.64.

Anal. Calcd. for $C_{10}H_{12}ClNO$: C, 60.75; H, 6.12. Found: C, 60.95; H, 6.22.

Ethyl N-p-chlorophenylacetimidate. Yield, 95%; b.p. 123–124° at 11.8 mm., n_D^{25} 1.5323, d_4^{25} 1.105; MR(calcd.) 55.13, MR(obs.) 55.45.

Anal. Calcd. for $C_{10}H_{12}ClNO$; C, 60.75; H, 6.12. Found: C, 61.16; H, 6.04.

Ethyl N-o-ethoxyphenylacetimidate. Yield, 88%; b.p. 127.5–128.5° at 13.5 mm., n_D^{25} 1.5129, d_4^{25} 1.008; MR(calcd.) 61.14, MR(obs.) 62.09.

Anal. Calcd. for $C_{12}H_{17}NO_2$: C, 69.53; H, 8.26. Found: C, 69.97; H, 8.25.

Ethyl N-p-ethoxyphenylacetimidate. Yield, 92%; b.p. 146–147° at 15.0 mm., n_D^{25} 1.5181, d_4^{25} 1.018; MR(calcd.) 61.14, MR(obs.) 62.00.

Anal. Calcd. for $C_{12}H_{17}NO_2$: C, 69.53; H, 8.26. Found: C, 69.77; H, 8.14.

Ethyl N-(2,6-diethylphenyl)acetimidate. Yield, 91%; b.p. 109–110° at 6.3 mm., n_D^{25} 1.5084, d_4^{25} 0.946; MR(calcd.) 68.73, MR(obs.) 69.18.

Anal. Calcd. for $C_{14}H_{21}NO$: C, 76.66; H, 9.65. Found: C, 77.10; H, 9.61.

Ethyl N-(3,4-dichlorophenyl)acetimidate. Yield, 95%; b.p. 110.5–111° at 0.99 mm., n_D^{25} 1.5487, d_4^{2} 1.221; MR(calcd.) 60.00, MR(obs.) 60.44.

Anal. Calcd. for $C_{10}H_{11}Cl_2NO$: C, 51.74; H, 4.77. Found: C, 51.91; H, 4.93.

Ethyl N-phenylpropionimidate. This ester was prepared by the procedure described above for preparation of ethyl *N*-arylacetimidates, using 0.20 mole of aniline and 0.23 mole of ethyl orthopropionate. Yield, 92.5%; b.p. 104–105° at 12.5 mm., n_D^{25} 1.5099, d_4^{25} 0.969; MR(calcd.) 54.88; MR(obs.) 54.72 (lit.[10] b.p. 103–105° at 13 mm., n_D^{20} 1.5126.)

Anal. Calcd. for $C_{11}H_{15}NO$: C, 74.53; H, 8.53. Found: C, 74.69; H, 8.49.

Ethyl N-(2,6-diethylphenyl)formimidate. This ester was prepared by the procedure described above for preparation of ethyl *N*-arylacetimidates, using 0.25 mole of 2,6-diethylaniline and 0.30 mole of ethyl orthoformate. Five hours of refluxing at atmospheric pressure was required to complete the reaction without addition of an acidic catalyst. In the absence of a catalyst, the yield of imidic ester was 90%; no *N,N'*-bis(2,6-diethylphenyl)-formamidine was obtained. In a second run, identical with the first except for addition of a small crystal of *p*-toluenesulfonic acid to the reaction mixture, the reaction proceeded to completion more rapidly than in the absence of added acid, but the yield of imidic ester was only 82%. The ester boiled at 146–147.5° at 26 mm., n_D^{25} 1.5079, d_4^{25} 0.958; MR(calcd.) 64.12, MR(obs.) 63.87.

Anal. Calcd. for $C_{13}H_{19}NO$: C, 76.05; H, 9.33. Found: C, 75.88; H, 9.04.

Reaction of aniline with ethyl N-phenylacetimidate. Run I. Aniline (1.86 g., 0.02 mole) and ethyl *N*-phenylacetimidate (3.26 g., 0.02 mole) were placed in a 25 ml. round bottomed flask fitted with a short air condenser, and a small crystal of *p*-toluenesulfonic acid monohydrate was added. The flask was heated at 140° in an oil bath for 4 min. and then cooled to room temperature. The reaction flask was then fitted with a Claisen head, adapter, and receiver, and the unchanged aniline and imidic ester were removed by flash distillation at 0.001 mm. The distillate, collected in a Dry Ice cooled receiver, weighed 5.02 g. This corresponds to a 98% recovery of starting material. A small amount of white, crystalline solid (assumed to be *N,N'*-diphenylacetamidine) remained on the walls of the reaction flask.

Run II. A reaction mixture of the same composition as that of run I was heated at 140° for 3.5 hr. Flash distillation of the reaction mixture yielded 3.84 g. of unchanged starting materials (75% recovery). The solid material remaining in the flask (1.20 g.) recrystallized from aqueous ethanol, yielding white needles of *N,N'*-diphenylacetamidine, m.p. 131–133° (lit., 132°[17]).

Run III. A reaction mixture of the same composition as that of run I was heated at 140° for 22 hr. Flash distillation of the reaction mixture yielded 2.26 g. of unchanged starting materials (44% recovery) and a dry, crystalline residue of *N,N'*-diphenylacetamidine.

Reaction of m-chloroaniline with ethyl N-m-chlorophenylacetimidate. *m*-Chloroaniline (2.55 g., 0.02 mole), ethyl *N-m*-chlorophenylacetimidate (3.95 g., 0.02 mole), and a small crystal of *p*-toluenesulfonic acid were mixed and heated for 3.5 hr. as described above. Flash distillation of the reaction mixture yielded 5.22 g. of unchanged starting materials (80% recovery). Recrystallization of the residue in the reaction flask from aqueous ethanol yielded *N,N'*-di-*m*-chlorophenylacetamidine m.p. 87–89°. (A sample prepared by the procedure of Bradley and Wright[18] melted at 86.5–87.5°[19]; no depression of melting point was observed on mixing the two samples.)

Reaction of p-ethoxyaniline with ethyl N-p-ethoxyphenylacetimidate. From an experiment similar to that described above, using 0.02 mole each of *p*-ethoxyaniline and ethyl *N-p*-ethoxyphenylacetimidate, 45% of the starting materials were recovered. The dry residue in the reaction flask (3.45 g.) was recrystallized from aqueous ethanol, yielding colorless crystals of *N,N'*-bis(*p*-ethoxyphenyl)acetamidine, m.p. 118–119° (lit. m.p. 117–118°[20]).

Alcoholysis of N,N'-diphenylacetamidine. Five milliliters of absolute ethanol and 1.70 g. of *N,N'*-diphenylacetamidine were placed in a 25-ml. round bottomed flask fitted with a condenser, and two small crystals of *p*-toluenesulfonic acid monohydrate were added. The mixture was heated at reflux for 22 hr. The reaction flask was fitted with a 10-cm. Vigreux column, and the ethanol was removed by distillation at 80 mm. The residue in the reaction flask was a white, slightly moist crystalline mass consisting mostly of unchanged *N,N'*-diphenylacetamidine. The reaction flask was connected to a Claisen head fitted with a vacuum take-off and receiver. The last traces of ethanol were allowed to evaporate by evacuating the system to 0.002 mm. at room temperature. The receiver was then cooled with a Dry Ice bath, and the reaction flask heated to about 150° at 0.001 mm. This caused

(15) Molal refractions were calculated using the atomic refractions of R. R. Dreisbach, *Physical Properties of Chemical Compounds*, Advances in Chemistry Series, No. 15, American Chemical Society, Washington, D.C., 1955, p. 9.

(16) Elementary analyses were performed by Australian Microanalytical Service, Chemistry Department, University of Melbourne, Parkville, N.2, Victoria, Australia.

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(18) W. Bradley and I. Wright, *J. Chem. Soc.*, 1618 (1948).

(19) R. H. DeWolfe and J. R. Keefe, *J. Org. Chem.*, **27**, 493, 1962.

(20) A. J. Hill and I. Rabinowitz, *J. Am. Chem. Soc.*, **48**, 732 (1926).

0.55 g. of colorless liquid to distill into the receiver. The residue in the reaction flask (unchanged diphenylacetamidine) solidified on cooling. The infrared spectrum of the distillate (determined with a Beckman IR-7 spectrophotometer) exhibited only peaks appearing in the spectra of authentic samples of aniline and ethyl *N*-phenylacetimidate. Twenty of these peaks (at 663, 870, 905, 930, 950, 1005, 1095, 1165, 1375, 1393, 1447, 1537, 1660, 1735, 1985, 2030, 2480, 2560, 2870, and 2980 wave numbers) appear in the spectrum of ethyl *N*-phenylacetimidate, but not in that of aniline. A rough quantitative calculation of the composition of the liquid reaction product from spectral transmittancy data showed that it consisted of approximately equimolar amounts of aniline and ethyl *N*-phenylacetimidate.

Preparation of N,N'-diphenylacetamidine from aniline and ethyl orthoacetate. A mixture of 0.4 mole (37.2 g.) of aniline, 0.2 mole (32.4 g.) of ethyl orthoacetate, and a few milligrams of *p*-toluenesulfonic acid monohydrate was heated in a 100-ml. round bottomed flask having a thermometer well and fitted with a Claisen head, adapter, and receiver. Ethanol distilled over rapidly at first, then much more slowly, and the temperature of the reaction flask rose from 90° to 196°. After 2.5 hr., evolution of ethanol had practically ceased. The reaction mixture was heated overnight at 170°. Upon cooling, it partially crystallized. Flash distillation of the reaction mixture at 0.001 mm., using a Dry Ice-cooled receiver, yielded 13.6 g. of liquid distillate whose infrared spectrum exhibited only peaks attributable to aniline and ethyl *N*-phenylacetimidate. The crude, crystalline N,N'-diphenylacetamidine remaining in the reaction flask weighed 30.4 g. (72%). Recrystallization from aqueous ethanol yielded 26.4 g. of colorless crystals, m.p. 134.5–136°. This corresponds to an over all yield of purified product of 63%.

Attempted preparation of ethyl N-phenylacetimidate from N,N'-diphenylacetamidine and ethyl orthoacetate. Ethyl orthoacetate (0.14 mole, 25 ml.), N,N'-diphenylacetamidine (0.10 mole, 21.0 g.), and a few milligrams of *p*-toluenesulfonic acid monohydrate were heated in a 50-ml. round bottomed flask fitted with a 15-cm. glass helix-packed column, total reflex-partial take-off still head, and receiver. A total of 8.22 g. of ethanol, b.p. 75–80°, was collected at the still head during a 22-hr. period (theoretical yield of ethanol for formation of ethyl *N*-phenylacetimidate, 4.6 g.). At this point the reaction mixture was cooled, whereupon it partially solidified. Reduced pressure distillation of the reaction mixture, using a 10-cm. semi-micro Vigreux column, yielded 8.25 g. of unchanged ethyl orthoacetate (b.p. 60–68° at 41.5 mm.), a small intermediate fraction, and 3.2 g. of a colorless liquid, b.p. 112–112.5° at 40.6 mm. At this point, distillation ceased and the temperature at the bottom of the Vigreux column rose to 180°. The residue in the reaction flask, assumed to be N,N'-diphenylacetamidine, solidified completely on cooling. The higher boiling distillate fraction had an odor similar to that of ethyl orthoacetate. Since its infrared spectrum was completely different from that of ethyl *N*-phenylacetimidate and showed no peaks assignable to C_6H_5—, this material is assumed to have been formed by decomposition of ethyl orthoacetate. Its identity was not established.

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Mechanism of Acid-Catalyzed Hydrolysis of N,N'-Diarylacetamidines

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The effects of aryl substituents, temperature, and solvent acidity on the rate of hydrolysis of symmetrically substituted N,N'-diarylacetamidines in acidic 20% dioxane solutions have been studied. The acetamidines hydrolyze by essentially the same mechanism as that previously proposed for N,N'-diarylformamidine hydrolysis, but are less than one one-thousandth as reactive. The reason for this unusually large reactivity difference between acetic acid and formic acid derivatives is discussed.

A recent study of the effect of aryl substituents, temperature, solvent polarity, solvent acidity, and nucleophilic catalysts on the rate of hydrolysis of N,N'-diarylformamidines [Equation (1), R = H]

$$\mathrm{Ar{-}NH{-}CR{=}N{-}Ar} + \mathrm{H_2O} \longrightarrow \mathrm{Ar{-}NH{-}CRO} + \mathrm{Ar{-}NH_2} \quad (1)$$

led to the conclusion that the reaction involves nucleophilic attack by water on hydrated amidinium ions.[1] In order to determine whether diarylacetamidines undergo acid hydrolysis [Equation (1), R = CH_3] by the same mechanism, and to assess the effect of the acetamidine C-methyl group on reactivity, a similar study of the hydrolysis of several symmetrical N,N'-diarylacetamidines was undertaken.

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EXPERIMENTAL

The dioxane used in the reaction solutions was purified by the procedure of Fieser.[2] Reagent grade inorganic chemicals were used in preparing all of the kinetic solutions. The symmetrically substituted N,N'-diarylacetamidines used in this study were prepared from the appropriate arylamines and acetanilides by the procedure of Bradley and Wright[3] or that of Oxley, Peak, and Short.[4] All are known compounds except N,N-di-*m*-chlorophenylacetamidine and N,N'-di-*p*-chlorophenylacetamidine.

N,N'-Di-m-chlorophenylacetamidine, m.p. 86.5–87.5°. *Anal.* Calcd. for $C_{14}H_{12}N_2Cl_2$: C, 60.22; H, 4.33. Found: C, 60.32; H, 4.37.

N,N'-Di-*p*-chlorophenylacetamidine, m.p. 115–116°.

(2) L. F. Fieser, *Experiments in Organic Chemistry*, Third ed., D. C. Heath and Co., New York, N. Y., 1955, p. 284.

(3) W. Bradley and I. Wright, *J. Chem. Soc.*, 646 (1956).

(4) P. Oxley, D. A. Peak, and W. F. Short, *J. Chem. Soc.*, 1618 (1948).