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The Chemistry of Triazine Derivatives II. The Acylation of 2,4,6-Trimethyl-*s*-triazine to Triazinyl Ketones and Their Facile Isomerization to Acetamidopyrimidines

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A series of triazinyl ketones has been prepared by acylating 2,4,6-trialkyl-*s*-triazines and these ketones have been isomerized to 4-acylamidopyrimidine derivatives. A possible mechanism for this isomerization is suggested.

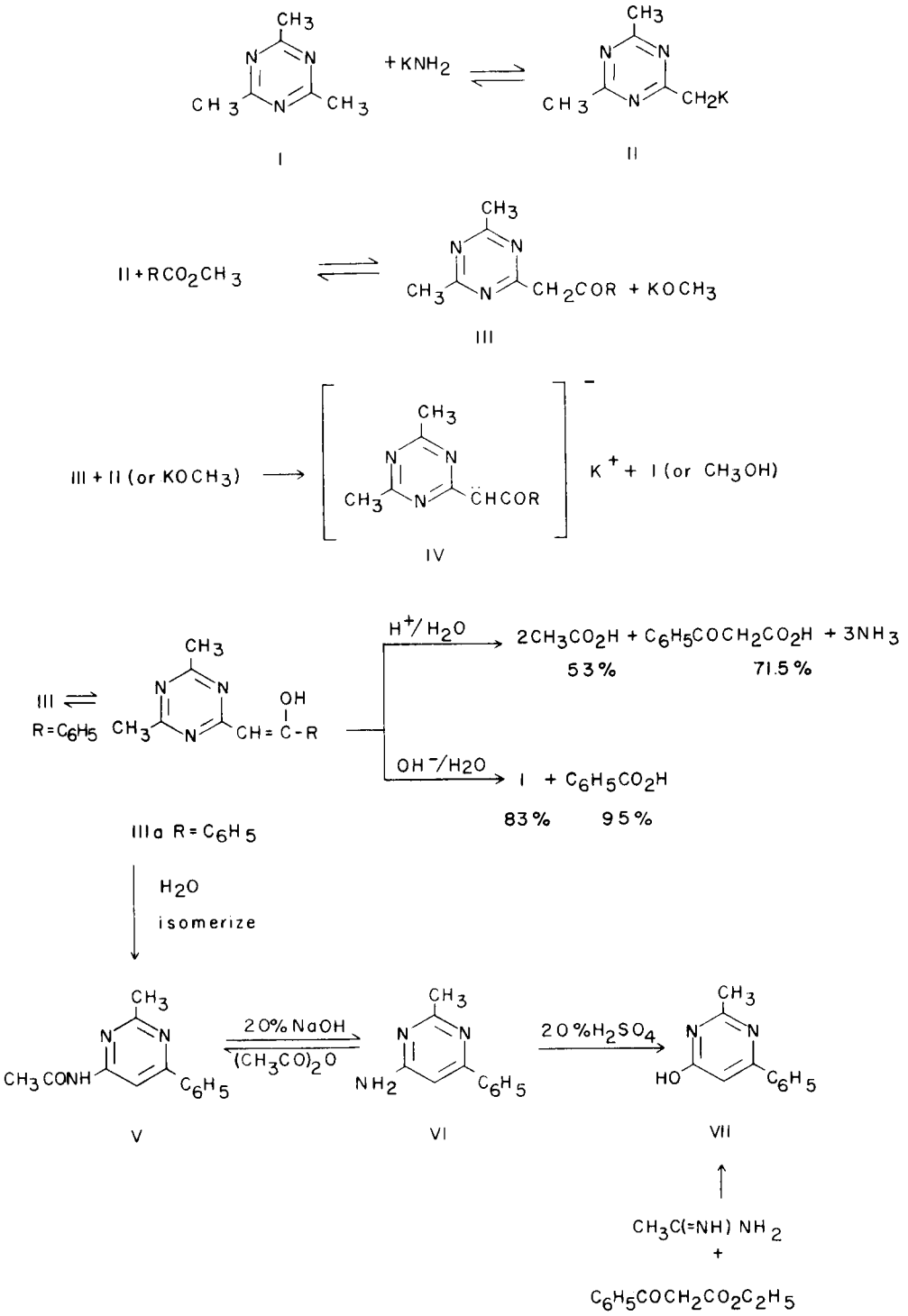
For a number of years organic chemists have been interested in the prototropic reactions of alkylated heterocyclic nitrogen compounds. The chemistry of the methyl groups of the isomeric picolines (3,4,5,6), lutidines (7), quinaldine and lepidine (7, 8, 9), which contain only one heterocyclic nitrogen atom has been extensively studied in these and other laboratories. Prototropic reactions have also been observed for methyl-substituted diazines, e.g., methylpyrimidines (10, 11, 12), methylpyridazines (13, 14) and methylpyrazines (15, 16, 17, 18). Under the appropriate reaction conditions these alkylated heterocyclic nitrogen compounds can take part in base-catalyzed prototropic reactions which are typical of active hydrogen compounds, e.g., acylation, alkylation and aldol-type condensation. In the case of alkylated heterocyclic nitrogen compounds containing three nitrogen atoms such as methylsubstituted-*s*-triazines only a limited number of base-catalyzed prototropic reactions appear to have been reported in the literature (19, 20, 21). In a recent communication (22) we reported the synthesis of a new class of ketones containing the triazine ring (III) by the acylation of 2, 4, 6-trimethyl-*s*-triazine (I) with a series of aromatic and heterocyclic esters in the presence of potassium amide in liquid ammonia and the facile isomerization of these ketones to acetamidopyrimidines. We now present a more detailed account of this and subsequent investigations.

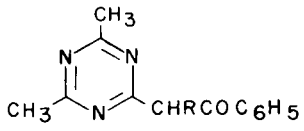
As an orienting reaction the acylation of I with methyl benzoate was investigated using four basic condensing agents. The yield of 2, 4-dimethyl-6-phenacyl-*s*-triazine (III, R = C_6H_5), varied from 0% when sodium amide or potassium amide in ether was used as the condensing agent to 74.5% when the reaction was effected in the presence of potassium amide in liquid ammonia. Intermediate yields of 1.7%, 26.8% and 56.5% were obtained using sodium methoxide in methanol, phenyllithium in ether and sodium amide in liquid ammonia, respectively. The overall reaction is indicated in the scheme in (Chart I), which is analogous to that previously proposed for the acylation of certain heterocyclic nitrogen compounds (9, 16, 23). Next, I was condensed with a series of esters in the presence of potassium amide in liquid ammonia to give ketones of the type (III), where R = alkyl, aryl or heterocyclic. The results are found in Table I.

Acid- and base-catalyzed hydrolyses, in which the triazine ring is ruptured to give carboxylic acids and ammonia, have been used as diagnostic tools in establishing the structures of trisubstituted-*s*-triazines (24). To determine whether our ketones would undergo such reactions, the acid- and base-catalyzed hydrolyses of III (R = C_6H_5) were studied. When III (R = C_6H_5) was treated with aqueous 2N sulphuric acid the expected cleavage products, acetic acid (53%), benzoylacetic acid (71.5%) and ammonia were obtained. However, when this ketone was subjected to basic hydrolysis the ring was not ruptured. Instead, cleavage occurred between the methylene and carbonyl groups to give benzoic acid (95%) and I (83%). That such cleavage occurred under basic conditions is not too surprising since III (R = C_6H_5) may be regarded as a 1, 3-diketone in which one of the carbonyl groups has been replaced by an azomethine function of the ring and 1,3-diketones are known to be cleaved readily by hydroxide ion (25). These cleavage reactions are shown in Chart I.

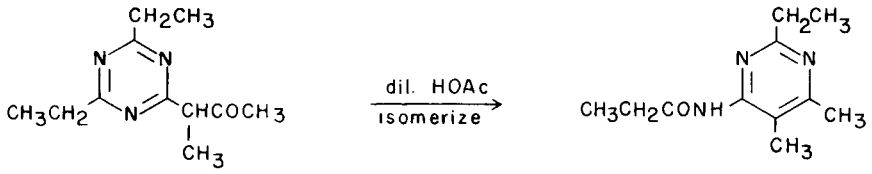
When III (R = C_6H_5) is isolated from the reaction mixture it is a somewhat broad melting pale, yellow solid m.p. 69-72°, even after repeated recrystallization from 60-70° petroleum ether. In spite of this, its elemental analysis was good. This broad melting range can be attributed to the existence of a keto-enol equilibrium (III-IIa) which was clearly shown to exist from a study of the infrared and proton n.m.r. spectra of the compound. Such keto-enol equilibria have previously been observed in certain other acylated heterocyclic nitrogen compounds (26, 27). In an attempt to obtain a sharper melting sample of III (R = C_6H_5) recrystallization

CHART I

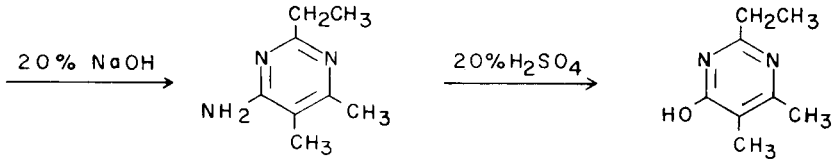

CH3
N
N
CH3
N
CH3
+KNH2
CH2K
I
II
II+RCO2CH3
CH2COR + KOCH3
III
III + II (or KOCH3)
K+ + I (or CH3OH)
CHCOR
IV
III ⇌
R=C6H5
OH
CH=C-R
H+/H2O
2CH3CO2H + C6H5COCH2CO2H + 3NH3
53%
71.5%
OH-/H2O
I + C6H5CO2H
83%
95%
IIIa R=C6H5
H2O
isomerize
CH3CONH
C6H5
20% NaOH
(CH3CO)2O
NH2
20% H2SO4
HO
V
VI
VII
CH3C(=NH) NH2
+
C6H5COCH2CO2C2H5



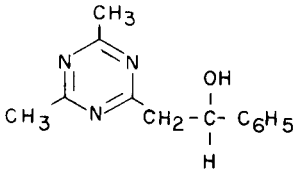
VIII



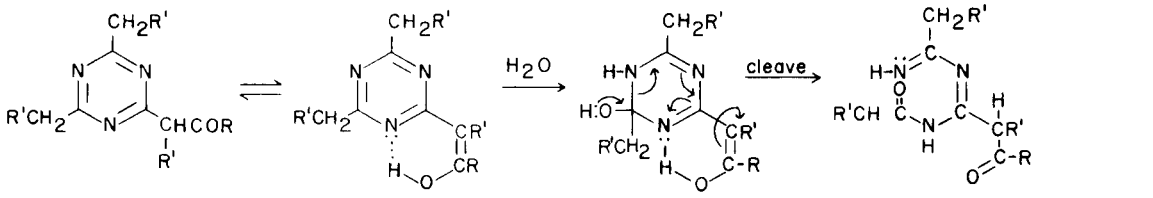
IX X



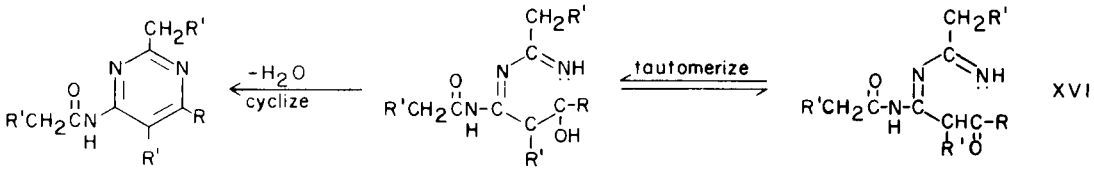
XI XII



XIII



XIV XIVa XV XVI



XVII XVIa XVI

R = alkyl, aryl or heterocyclic

R' = H or CH_3

TABLE I

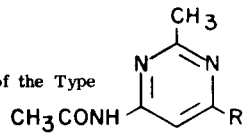
Ketones of the Type III Prepared by Condensing 2,4,6-Trimethyl-*s*-triazine with Esters (RCO_2CH_3) in the Presence of Potassium Amide in Liquid Ammonia (a)

				Analyses (b)					Analyses (b)			
				% Carbon		% Hydrogen		Monopicrate	% Carbon		% Hydrogen	
R	Yield	m.p. (c)	b.p./mm.	Calcd.	Found	Calcd.	Found	m.p. (d)	Calcd.	Found	Calcd.	Found
C_6H_5	74.5 61.6 (g)	69-72	145-150/0.5	68.72	68.43	5.73	5.47 (e)	178-179 (f)	50.00	49.74	3.51	3.53
2-C_4H_3O (h)	90.0	89-93	145-150/0.6	60.84	60.61	5.07	5.14	154-155	45.74	45.32	3.17	3.09
2-C_4H_3S (i)	60.0	79-83	170-174/1.0	56.67	56.37	4.72	4.71	178-179	44.17	44.25	3.06	2.96
2-C_5H_4N (j)	79.0	110-114	195-205/0.8	63.13	63.32	5.31	5.31	155-156	47.26	47.81	3.31	3.49
3-C_5H_4N (k)	74.6	123.5-125	180-185/1.4	63.13	62.86	5.31	5.25	159.5-160.5	47.26	47.24	3.31	3.66
p-Cl-C_6H_4	88.0	167-168	--- (l)	59.45	59.63	4.57	4.54	157-159	45.63	45.76	3.02	3.00
p-OCH_3-C_6H_4	24.6	120-121	180-190/1.0	65.37	65.21	5.84	5.88	160.5-161.5	49.38	49.36	3.74	3.78
CH_3	54.1	65-66	94-100/5.0	58.15	58.38	6.72	6.52	147-148	42.64	42.67	3.59	3.72
C_2H_5	45.8	---	113-114/9.0	60.30	60.25	7.32	7.59	--- (m)	---	---	--	--
C_3H_7	18.1	---	118-119/2.5	62.14	62.09	7.84	7.82	--- (m)	---	---	--	--

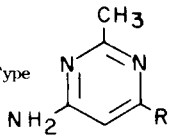
(a) A 2:2:1 molar ratio of reactants 2,4,6-trimethyl-*s*-triazine to potassium amide to ester was used in all the reactions unless otherwise stated. (b) Analyses were performed by Galbraith Microanalytical Laboratories, Knoxville, Tennessee. (c) Recrystallized from petroleum ether or benzene-petroleum ether mixtures. (d) Recrystallized from absolute ethanol. (e) *Anal.* Calcd., N, 18.51; Found, N, 18.31. (f) The compound also formed an oxime m.p. 152-153 from an ethanol-water mixture and a copper chelate derivative m.p. 164-165 after washing with an ethanol-water mixture. (g) Using a 1:1:1 molar ratio of reactants. (h) 2-C_4H_3O = 2-furyl radical. (i) 2-C_4H_3S = 2-thienyl radical. (j) 2-C_5H_4N = 2-pyridyl radical. (k) 3-C_5H_4N = 3-pyridyl radical. (l) The product was not distilled. (m) The compound would not form a picrate or oxime derivative.

TABLE II

Acetamidopyrimidines of the Type



and Aminopyrimidines of the Type



Prepared by Isomerization of Triazinyl Ketones

		Analyses (a)					Analyses (a)			
Acetamido		% Carbon		% Hydrogen		Amino-		% Carbon		% Hydrogen	
pyrimidine R =	m.p. (b)	Calcd.	Found	Calcd.	Found	pyrimidine R =	m.p. (b)	Calcd.	Found	Calcd.	Found
C_6H_5 (h)	169-170	68.72	68.93	5.73	5.58 (c)	C_6H_5	164-165 (d)	---	---	--	--
2-C_4H_3O (e)	194-195	60.84	60.93	5.17	5.34	2-C_4H_3O	171-172	61.69	61.45	5.19	5.48
2-C_4H_3S (e)	236-237	56.67	56.98	4.72	4.83	2-C_4H_3S	173-174	56.51	56.58	4.75	4.51
3-C_5H_4N (e)	222-223	63.13	62.90	5.31	5.61	3-C_5H_4N	226-227	64.49	64.86	5.42	5.36
2-C_5H_4N (e)	186.5-187.5	63.13	62.90	5.31	5.37	2-C_5H_4N	198-199	64.49	64.54	5.42	5.52
p-ClC_6H_4	175-176 (i)	59.45	59.73	4.57	4.35	*p*-ClC_6H_4	180-181	60.13	60.15	4.60	4.69
p-$OCH_3C_6H_4$	176-177	65.34	65.63	5.84	6.09	*p*-$OCH_3C_6H_4$	196-197	66.95	67.37	6.10	6.28
CH_3	186-187 (g)	---	---	--	--	CH_3 ---	180-181 (f)	---	---	--	--
C_2H_5	163-164	60.30	60.69	7.32	7.62	C_2H_5	148-149	61.27	60.92	8.10	8.06
C_3H_7	132-133	62.14	62.02	7.84	7.79	C_3H_7	134-135	63.53	63.55	8.68	8.51

(a) Analyses were performed by Galbraith Microanalytical Laboratories, Knoxville, Tennessee. (b) Recrystallized from benzene-petroleum ether mixtures. (c) *Anal.* Calcd., N, 18.51; Found, N, 18.29. (d) Lit. value 165°, see reference (31). (e) For the meaning of these symbols see Table I. (f) Alone and when mixed with an authentic sample, see A. R. Ronzio and W. B. Cook, Organic Synthesis, **24**, p. 6. (g) Alone and when mixed with an authentic sample, see reference (41). (h) A molecular weight determination on this compound using a Mechrolab vapor phase osmometer gave, Calcd: 227.3; Found: 227.7. (i) This isomerization took four hours.

TABLE III

Miscellaneous Compounds

		Analyses			
		% Carbon		% Hydrogen	
Compound (a)	m.p. or b.p./mm	Calcd.	Found	Calcd.	Found
IX (b)	116/4.5 mm	63.73	63.78	8.28	8.37
X (c)	80-81° (f)	63.73	63.80	8.27	8.41
XI	197-198° (d,h)	63.53	63.70	8.68	8.68
XII	166-167° (e,h)	---	---	--	--
XIII (f)	60-61° (g)	68.09	67.76	6.61	6.40

(a) For structures of compounds (IX-XIII) see Chart I. (b) Prepared in 54.3% yield from 2,4,6-triethyl-*s*-triazine and ethyl acetate in the presence of potassium amide in liquid ammonia. (c) The isomerization of IX to X was effected in the presence of 0.1 molar acetic acid. (d) Lit. value m.p. 204°, A. Pinner, *Ber.*, **22**, 1600 (1889). (e) Lit. value m.p. 165°, see reference (33). (f) Prepared in 38.4% yield from benzaldehyde and *s*-trimethyltriazine in the presence of potassium amide in liquid ammonia, using a 2:2:1 molar ratio of reactants, *s*-trimethyltriazine to potassium amide to benzaldehyde respectively. (g) Recrystallized from 30-60° petroleum ether. (h) Recrystallized from a mixture of benzene and 60-70° petroleum ether.

from ethanol-water mixtures was investigated. However, when a sample was recrystallized from aqueous ethanol or heated in refluxing distilled water it changed from a low, broad melting (m.p. 69-72°) yellow solid to a high, sharp melting (m.p. 169-170°) white solid (V).

In contrast with III (R = C_6H_5) compound V appeared to be inert to dilute acid or alkali. While III (R = C_6H_5) formed both an oxime and a copper chelate, neither of these reactions was shown by V. However, III and V showed essentially the same elemental analysis. Also a molecular weight determination on V indicated that there had been no change in molecular weight when III (R = C_6H_5) was converted to V. Thus III and V are isomers.

Based on (1) the fact that III lost its ketonic properties when it was isomerized to V and (2) an examination of the infrared spectrum of V which showed absorption at 1690 cm^{-1} (characteristic of a carbonyl group) and at 3350 cm^{-1} (characteristic of either -OH or -NH) and no longer showed the strong broad absorption in the region 1540-1560 cm^{-1} (characteristic of the triazine ring (28, 29), which was present in the starting material III); it was concluded that (a) although there is a carbonyl group in V it is probably part of an amide function and (b) the triazine ring has been destroyed. A sample of V was then heated in refluxing 20% sodium hydroxide solution for one hour. In this way there was obtained a compound VI, m.p. 164-165°, whose infrared spectrum no longer showed the presence of an amide carbonyl band but did show the presence of three absorption bands which are typical of mono-N-heterocyclic amines (30), *viz.*, a doublet at 3500 cm^{-1} and 3400 cm^{-1} and a third band at 1600 cm^{-1}.

Thus, it appeared that compound VI might be an aminodiazine, possibly an aminopyrimidine. A survey of the literature revealed that 4-amino-2-methyl-6-phenylpyrimidine has been prepared (31), m.p. 165°, identical with that of compound VI. Thus it was suspected that compound VI was 4-amino-2-methyl-6-phenylpyrimidine. It was further shown that compound V is quantitatively regenerated from VI by reaction with acetic anhydride. Thus, there appeared to be little doubt that compound V which is formed by the isomerization of III (R = C_6H_5) is 4-acetamido-2-methyl-6-phenylpyrimidine (V).

Additional evidence was obtained which not only confirms the structure of the amide (VI) but in turn confirms the structure of the amide (V). Thus, the ultraviolet absorption spectrum of VI was identical with the reported spectrum of an authentic sample of 4-amino-2-methyl-6-phenylpyrimidine (31). Finally a sample of VI was hydrolyzed with 20% sulfuric acid to give 4-hydroxy-2-methyl-6-phenylpyrimidine (VII), m.p. 242° (32) alone and when mixed with an authentic sample [prepared by the reaction of ethyl benzoylacetate with acetamidine (33)]. The reactions described above are summarized in Chart I. The analogous series of reactions was also effected where the phenyl radical in compounds (III-VII) was replaced by the 2-pyridyl group and the end product 4-hydroxy-2-methyl-6-(2-pyridyl)pyrimidine shown to be identical with an authentic sample prepared from acetamidine and methyl picolinylacetate (34).

All the triazinyl ketones in Table I (unless otherwise stated) were readily and essentially quantitatively isomerized to acetamidopyrimidines by reaction with refluxing distilled water for one to two hours. In addition, all the acetamidopyrimidines were quantitatively hydrolyzed to the corresponding aminopyrimidines by reaction with 20% sodium hydroxide solution for one hour. The results of these experiments are found in Table II.

In order to determine the scope and limitations of the isomerization, attempts were then made to prepare ketones of the type VIII by alkylating III (R = C_6H_5) in the presence of potassium amide in toluene according to the method which was used in the pyridine series (35), since ketones of this type appeared to offer a route to tetrasubstituted pyrimidines. These reactions however failed to produce any of the desired ketones. As an alternative route to tetrasubstituted pyrimidines *via* the isomerization of triazinyl ketones, studies were then made on compound IX which was prepared by acetylating 2,4,6-triethyl-*s*-triazine. This gave the expected series of compounds (X-XII) as is shown in Chart I. In this case, however, the isomerization was effected by refluxing in a 0.1 molar solution of acetic acid for three hours, which gave the isomerized product, 4-propionamido-2-ethyl-5, 6-dimethylpyrimidine (X) in 52.5% yield. No appreciable isomerization appeared to occur when IX was refluxed in distilled water for three hours. The results of these experiments are given in Table III.

The isomerization of triazinyl ketones to acetamidopyrimidines is extremely interesting because of the very mild conditions which were employed and the essentially quantitative yields which have been obtained. In this connection it should be pointed out that although triazines have been postulated (36) or used (37, 38) as intermediates in the syntheses of pyrimidine derivatives and pyrimidines have been used as intermediates in the synthesis of triazine derivatives (39, 40), there appear to be only two reported examples of the isomerization of trisubstituted-*s*-triazines to pyrimidines. Thus, 2,4,6-triethyl-*s*-triazine has been isomerized to 4-amino-2,6-diethyl-5-methylpyrimidine in 32% yield and 2,4,6-trimethyl-*s*-triazine has been isomerized to 4-amino-2,6-dimethylpyrimidine in 12% yield by reaction with methanolic ammonia under extremely drastic conditions, *viz.*, 150° at 8500 psi for twelve hours (41).

Since drastic conditions are required to isomerize trialkyl-*s*-triazines the role of the ketonic substituent in the 6-position appears to be important in the facile

isomerizations of triazinyl ketones to pyrimidines. This is to some extent further supported by the fact that compound (XIII) 1-phenyl-2-(2,4-dimethyl-6-triazyl) ethanol (see Table III and Chart I) does not undergo any reaction under the conditions employed for the isomerization of the triazinyl ketones.

One of several possible schemes which rationalizes the isomerization of triazinyl ketones to acetamidopyrimidines is given in Chart I. Thus water is envisioned as adding to the chelated enol form of the ketone XIVa to produce XV. This cleaves to give XVI which is in equilibrium with its enol form XVIa. Then, XVIa cyclizes with the loss of water to give a 4-acylamidopyrimidine XVII.

EXPERIMENTAL

In this section four typical experiments are described.

(a) The preparation of 2,4-dimethyl-6-phenacyl-*s*-triazine.

To potassium amide (0.1 mole) in 150 ml. of anhydrous liquid ammonia was added 2,4,6-trimethyl-*s*-triazine (42) (0.1 mole, 12.3 g.), dissolved in 25 ml. of anhydrous ether. During the addition, the color of the solution changed from green to yellow, to red brown, color changes occuring at approximately one third, two thirds and complete addition of the ethereal solution of 2,4,6-trimethyl-*s*-triazine. The resulting solution was stirred for one hr. Methyl benzoate (0.05 mole, 6.8 g.) in 10 ml. of anhydrous ether was added and the resulting solution was stirred for an additional one hr. period. The ammonia was replaced by anhydrous ether and after all the ammonia had evaporated the reaction mixture was poured onto a mixture of crushed ice and 11.5 ml. of concentrated hydrochloric acid. Any excess acid was neutralized by the addition of solid sodium bicarbonate and after separating the ether phase, the residual aqueous phase was extracted with several portions of chloroform. Distillation of the combined ether and chloroform extracts gave, in addition to recovered 2,4,6-trimethyl-*s*-triazine and methyl benzoate, 8.45 g. (74.5%) of 2,4-dimethyl-6-phenacyl-*s*-triazine, b.p. 145-150° at 0.5 mm.: m.p. 69-72° from 60-70° petroleum ether.

(b) The isomerization of 2,4-dimethyl-6-phenacyl-*s*-triazine to 4-acetamido-2-methyl-6-phenylpyrimidine.

2,4-Dimethyl-6-phenacyl-*s*-triazine (4.0 g.) was refluxed with 60 ml. of distilled water for one hr. During this period the compound changed from a yellow oil to a white crystalline solid. The solution was cooled and extracted with several portions of chloroform. Removal of the solvent from the dried chloroform extracts gave a quantitative yield of 4-acetamido-2-methyl-6-phenylpyrimidine, m.p. 169-170° from a mixture of benzene and 60-70° petroleum ether.

(c) The hydrolysis of 4-acetamido-2-methyl-6-phenylpyrimidine to 4-amino-2-methyl-6-phenylpyrimidine.

4-Acetamido-2-methyl-6-phenylpyrimidine (1.0 g.) was refluxed for one hr. with 20 ml. of 20% sodium hydroxide solution. The solution was cooled and extracted with several portions of chloroform. Removal of the solvent from the dried chloroform extracts gave a quantitative yield of 4-amino-2-methyl-6-phenylpyrimidine, m.p. 164-165° from a mixture of benzene and 60-70° petroleum ether.

(d) Conversion of 4-amino-2-methyl-6-phenylpyrimidine to 4-hydroxy-2-methyl-6-phenylpyrimidine.

4-Amino-2-methyl-6-phenylpyrimidine (0.5 g.) was refluxed for five hrs. with 10 ml. of 20% by volume sulphuric acid. The reaction mixture was cooled, made basic by the addition of sodium hydroxide solution and then filtered (or extracted with chloroform) to remove any unreacted amine. The filtrate was acidified by the addition of acetic acid and the solution filtered (or extracted with chloroform) to give 4-hydroxy-2-methyl-6-phenylpyrimidine recrystallized from an ethanol-water mixture, m.p. 242° alone and when mixed with an authentic sample (33).

REFERENCES

(1) This paper is based on part of the thesis submitted by D. R. O. to the Graduate Faculty of the University of Pittsburgh in partial fulfillment of the requirements for the Ph.D. degree.
(2) Undergraduate honors research participant.
(3) C. Osuch and R. Levine, *J. Am. Chem. Soc.*, **78**, 1723 (1956).
(4) H. C. Brown and W. A. Murphey, *ibid.*, **73**, 3308 (1951).
(5) S. Raynolds and R. Levine, *ibid.*, **82**, 472 (1960).
(6) C. Osuch and R. Levine, *J. Org. Chem.*, **22**, 939 (1957).
(7) N. N. Goldberg and R. Levine, *J. Am. Chem. Soc.*, **74**, 5217 (1952).
(8) F. W. Bergstrom, T. R. Norton and R. A. Seibert, *J. Org. Chem.*, **10**, 452 (1945).
(9) M. J. Weiss and C. R. Hauser, *J. Am. Chem. Soc.*, **71**, 2023 (1949).
(10) W. Pfleiderer and M. Mosthaf, *Ber.*, **90**, 728 (1957).
(11) T. D. Heyes and J. C. Roberts, *J. Chem. Soc.*, 328 (1951).
(12) H. R. Sullivan and W. T. Caldwell, *J. Am. Chem. Soc.*, **77**, 1559 (1955).
(13) R. H. Mizzoni and P. K. Spoerri, *ibid.*, **76**, 2201 (1954).
(14) O. Poppenberg, *Ber.*, 34, 3257 (1901).
(15) J. D. Behun and R. Levine, *J. Am. Chem. Soc.*, **81**, 5666 (1959).
(16) J. D. Behun and R. Levine, *ibid.*, **81**, 5157 (1959).
(17) M. R. Kamal and R. Levine, *J. Org. Chem.*, 27, 1360 (1962).
(18) M. R. Kamal and R. Levine, *ibid.*, 29, 191 (1964).
(19) C. Grundmann, H. Ulrich and A. Kreutzberger, *Ber.*, **86**, 181 (1953).
(20) C. Grundmann and G. Weise, *ibid.*, **84**, 684 (1951).
(21) C. Grundmann and V. Mini, *J. Org. Chem.*, **29**, 678 (1964).
(22) D. Osborne and R. Levine, *ibid.*, **28**, 2933 (1963).
(23) N. N. Goldberg, L. B. Barkley and R. Levine, *J. Am. Chem. Soc.*, 73, 4301 (1951).
(24) E. M. Smolin and L. Rapoport, "The Chemistry of Heterocyclic Compounds, *s*-Triazine and Derivatives", Interscience Publishers Inc. New York, New York, (1959), p. 162.
(25) C. R. Hauser, F. W. Swamer and B. I. Ringler, *ibid.*, 70, 4023 (1948).
(26) R. F. Branch, *Nature*, **177**, 671 (1956).
(27) R. F. Branch, *ibid.*, **179**, 42 (1957).
(28) W. M. Padgett II, and W. F. Hamner, *J. Am. Chem. Soc.*, **80**, 803 (1958).
(29) H. K. Reimschuessel and N. T. McDevitt, *ibid.*, **82**, 3756 (1960).
(30) S. F. Mason, *J. Chem. Soc.*, 1281 (1959).
(31) P. B. Russell, *ibid.*, 2951 (1954).
(32) G. Shaw and G. Sugowdz, *ibid.*, 665 (1954).
(33) A. Pinner, *Ber.*, 22, 1612 (1889).
(34) A. Pinner, *ibid.*, 34, 4234 (1901).
(35) A. H. Beckett and K. A. Kerridge, *J. Chem. Soc.*, 2948 (1954).
(36) D. B. Lake and T. E. Londergan, *J. Org. Chem.*, **19**, 2004 (1954).
(37) A. Kreutzberger and C. Grundmann, *ibid.*, **26**, 1121 (1961).
(38) F. C. Schaefer, K. R. Huffmann and G. A. Peters, *ibid.*, **27**, 548, 551 (1962).
(39) E. C. Taylor, C. W. Jefford and C. C. Cheng, *J. Am. Chem. Soc.*, **83**, 1261 (1961).
(40) E. C. Taylor and C. W. Jefford, *ibid.*, **84**, 3744 (1962).
(41) T. L. Cairns, A. W. Larchar and B. C. McKusick, *ibid.*, **74**, 5633 (1952).
(42) F. C. Schaefer and G. A. Peters, *J. Org. Chem.*, **26**, 2778 (1961).

Received May 6, 1964

Pittsburgh, Pa.