and the solids were washed with methylene chloride. Evaporation of the filtrate gave an oily residue (19.0 g.) which was extracted with pentane. The pentane solution was concentrated and the residue was distilled, yielding 11.6 g. of oil, b.p. 120° (35 mm.). Analysis by g.l.c. showed it to contain (i) 8.6 g. (44.0% yield) of 2,4-diethyl-6-isopropoxy-s-triazine (VIII) which could be isolated in various ways, one of which is described below and (ii) 3.1 g. (15.5% yield) of 2-chloro-4-ethyl-6-isopropoxy-s-triazine (IX), the sample of which was isolated *via* g.l.c.: $n^{27}D$ 1.4870; infrared absorption, 1545 and 1505 (triazine ring stretching), and 909, 880, and 825 cm.$^{-1}$ (all three common to chloroalkylalkoxy-s-triazines).

Anal. Calcd. for $C_8H_{12}ClN_3O$: C, 47.64; H, 6.00; Cl, 17.58; N, 20.84. Found: C, 47.66; H, 6.15; Cl, 18.35; N, 20.90.

B.[18]—After filtration of the inorganic salts, 20 g. of ethylene glycol and 4.12 g. of 50% sodium hydroxide solution were added to the methylene chloride filtrate and the solvent was distilled at atmosphere pressure to one-eighth of the original volume. A check by g.l.c. indicated complete conversion of 2-chloro-4-ethyl-6-isopropoxy-s-triazine to the 2-hydroxyethyl derivative. Water (100 ml.) was added and, after separation of the organic layer, the aqueous layer was re-extracted with methylene chloride. Removal of the solvent from the organic layer and distillation of the residue gave 7.8 g. (40.1%) of 2,4-diethyl-6-isopropoxy-s-triazine (VIII): b.p. 125–127° (26 mm.); $n^{30}D$ 1.4688; λ_{max} 238 mμ (ε 2450); infrared absorption, 1555 (shoulder) and 1540 (triazine ring stretching), and 917 and 838 cm.$^{-1}$ (common to other dialkylalkoxy-s-triazines).

Anal. Calcd. for $C_{10}H_{17}N_3O$: C, 61.51; H, 8.78; N, 21.52. Found: C, 61.52; H, 8.55; N, 21.34.

Combined distillation residues yielded, on fractionation, 2-ethyl-4-isopropoxy-6-(2-hydroxyethoxy)-s-triazine: b.p. 127–130° (0.1 mm.); $n^{27.5}D$ 1.4919; λ_{max} 235 mμ (ε 2800); infrared absorption, 3350 (OH), 1555 and 1540 (shoulder) (triazine ring), and 908, 885, and 830 cm.$^{-1}$.

(18) With E. O'Bara.

Anal. Calcd. for $C_{10}H_{17}N_3O_3$: C, 52.85; H, 7.54; N, 18.49. Found: C, 52.90; H, 7.71; N, 18.53.

2,4-Diethyl-6-ethoxy-s-triazine (XVII) was obtained from run 20. An analytical sample of this compound and of the compounds which follow was secured by g.l.c. separation[12]: $n^{25}D$ 1.4731; infrared absorption, 1595, 1545, 912, and 840 cm.$^{-1}$.

Anal. Calcd. for $C_9H_{15}N_3O$: C, 59.64; H, 8.34; N, 23.19. Found: C, 59.73; H, 8.51; N, 23.15.

2-Ethyl-4,6-diethoxy-s-triazine (XVIII) was obtained from run 15: $n^{25}D$ 1.4772; infrared absorption, 1560, 1545, 945, 863, and 832 cm.$^{-1}$.

Anal. Calcd. for $C_9H_{15}N_3O_2$: C, 54.80; H, 7.61; N, 21.30. Found: C, 54.65; H, 7.41; N, 21.27.

2-Ethyl-4,6-diisopropoxy-s-triazine (XIX) was obtained from run 16: $n^{30}D$ 1.4688; infrared absorption, 1570, 1550, 968, 908, and 833 cm.$^{-1}$.

Anal. Calcd. for $C_{11}H_{19}N_3O_2$: C, 58.62; H, 8.50; N, 18.65. Found: C, 58.50; H, 8.35; N, 18.62.

6-Chloro-4-ethyl-6-methoxy-s-triazine (XXI) was isolated from run 19: m.p. 38–40°; infrared absorption, 1555, 1520, 924, 873, and 826 cm.$^{-1}$.

Anal. Calcd. for $C_6H_8ClN_3O$: C, 41.51; H, 4.65; Cl, 20.43; N, 24.21. Found: C, 41.47; H, 4.63; Cl, 20.50; N, 24.28.

2-Chloro-4-ethyl-6-ethoxy-s-triazine (XXII) from run 20 had $n^{25}D$ 1.4946 and infrared absorption at 1555, 1545, 1510, 964, 900, and 825 cm.$^{-1}$.

Anal. Calcd. for $C_7H_{10}ClN_3O$: C, 44.82; H, 5.37; Cl, 18.90; N, 22.40. Found: C, 44.66; H, 5.51; Cl, 18.46; N, 22.10.

Acknowledgment.—We wish to express our thanks to the following: Professor F. Ramirez (New York State University, College on Long Island) for most helpful discussions, Dr. J. E. Lancaster (Central Research Division) for n.m.r. spectra, Mr. John J. Kobliska and his staff for the microanalyses, and Dr. J. Parsons for some of the large-scale isolations of samples by g.l.c.

s-Triazines. IV.[1a] Synthesis of Trisubstituted s-Triazines by Reaction of Acylimidates with Amidines

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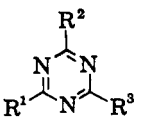
Reaction of acylimidates with amidines at room temperature affords a practical route to hitherto inaccessible trisubstituted s-triazines bearing three different substituents. These may be alkyl or aryl groups, or one of them can be an alkoxy, alkylthio, or amino group.

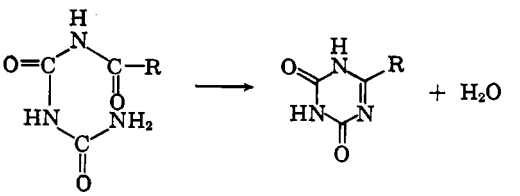
The principal methods of synthesis of alkyl- and aryl-s-triazines are based on trimerization or cotrimerization of nitriles, amidines, or imidates.[2,3] Consequently they are suitable for the preparation of s-triazines possessing three identical substituents (I) or of those containing two types of substituents (II).



I, $R^1 = R^2 = R^3$ = alkyl or aryl
II, $R^1 = R^2$ = alkyl or aryl; R^3 = alkyl, aryl, OR, SR NH_2, NHR, etc.

This paper describes the first preparative method for s-triazines bearing three different alkyl or aryl substituents. One of these can also be an alkoxy, alkylthio, or amino group.

This investigation arose from the consideration of the facile ring closures of acylbiurets (III) to guanamines, first described by Ostrogovich[4] and more recently investigated by Kaiser and co-workers.[5] The latter extended this method to acylcyanoguanidines



III

(1) (a) Part III: H. Bader, *J. Org. Chem.*, **30**, 930 (1965). (b) To whom correspondence should be addressed at Aldrich Chemical Co., Milwaukee, Wis.

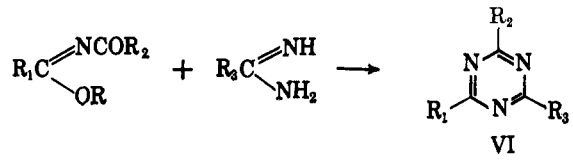
(2) E. M. Smolin and L. Rapoport, "s-Triazines and Derivatives," Interscience Publishers, Inc., New York, N. Y., 1959, Chapter II.

(3) (a) F. C. Schaefer, I. Hechenbleikner, G. A. Peters, and V. P. Wystrach, *J. Am. Chem. Soc.*, **81**, 1466 (1959); (b) F. C. Schaefer and G. A. Peters, *J. Org. Chem.*, **26**, 2778 (1961); (c) F. C. Schaefer, *ibid.*, **27**, 3362 (1962); (d) *ibid.*, **27**, 3608 (1962).

(4) For an account of the work of Ostrogovich, see ref. 2, pp. 203–204.

(5) P. Adams, D. W. Kaiser, D. E. Nagy, G. A. Peters, R. L. Sperry, and J. T. Thurston, *J. Org. Chem.*, **17**, 1162 (1952); D. W. Kaiser and J. T. Thurston, *ibid.*, **17**, 185 (1952).

TABLE I
SYNTHESES OF TRIAZINES VI



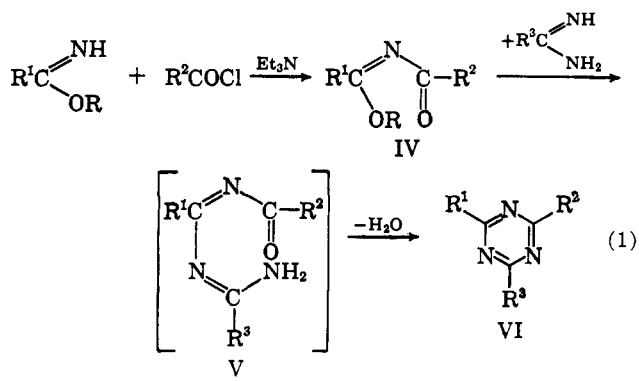
VI

Expt. no.	R_1	R_2	R_3	R	Solvent[a]	Time, days	Yield, % VI	Other triazines[b]	Other by-products R_2CONH_2	Other by-products R_1CO_2Me
1a	Et	PhCH=CH	Me	*i*-Pr	*t*-BuOH	4	VIa, 53.3		*c*	
1b					A	3	28.0		9.9	8.0
2	Et	PhCH=CH	MeO	*i*-Pr	MeOH	3	VIb, 15.6	Et_3, 0.23; $Et_2(OMe)$, 2.3; $Et(OMe)_2$, 2.3; $Et(NH_2)$-(OMe), 27.2	53.4	
3	Et	PhCH=CH	NH_2	*i*-Pr	*t*-BuOH	1	VIc, 27.1	$Et(NH_2)_2$, 38.3	39.1	
4	Et	Et	MeO	*i*-Pr	A	3	VId, 38.6	Et_3, 7.6; $Et(OMe)_2$, 6.3; $Et(NH_2)(OMe)$, 33.8		
5	Et	Me	MeO	*i*-Pr	A	5	VIe, 43.6	Et_2Me,[d] 2.9; Et_3, 0.9; Et_2-(OMe), 11.3; $Et(OMe)_2$, 12.1		
6	Et	Ph	MeS	*i*-Pr	*t*-BuOH	3	VIf, 9.9	Et_3, 0.8; $Et_2(SMe)$,[e] 7.4	80.0	
7	Et	Ph	Me	*i*-Pr	*t*-BuOH	2	VIg, 6.2	$EtMe_2$,[d] 35.0; $PhEt_2$, 3.0[f]	*c*	
8	Ph	Et	MeS	Me	A	3	VIf, 25.0	PhEt(OMe), 6.5		5.1
9	Ph	Et	Me	Me	A	3	VIg, 47.6	$PhMe_2$,[f] 2.2	*c*	1.2

[a] A, 1:2.5 to 1:3 methanol–ether mixture. [b] The 2,4,6-substituents of *s*-triazine are abbreviated; *viz.* Et_3 means triethyltriazine, $Et_2(OMe)$ means 2,4-diethyl-6-methoxy-*s*-triazine. [c] Identified, but not isolated quantitatively. [d] Identified through analysis, g.l.c., n_D, and infrared spectra comparison with an authentic sample (ref. 3c). [e] Identified in the same manner by comparison with authentic sample (ref. 3d). [f] Tentatively identified on the basis of g.l.c. data and infrared spectra.

which gave alkyl(or aryl)aminohydroxy-*s*-triazines and to carbethoxydicyandiamide which yielded ammelide. The aim of the present work is to extend this synthesis to triazines substituted with two or three different alkyl or aryl groups.

The synthetic route used is shown by the following sequence.



IV V VI (1)

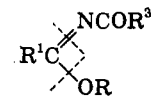
Acylimidates (IV) were originally reported by Wheeler and his collaborators[6] in 1897 and (with the exception of sulfonylimidates) have not attracted attention since.[7] In the present work the conditions of acylation of imidates with acid chlorides were only modified by the use of an organic base as the acid acceptor. These intermediates were thus obtained in 60–90% yields. They were stable on storage in the absence of moisture.

Reactions of acylimidates with ammonia and with primary amines were shown by Wheeler and his coworkers[6] to give acylamidines. Similarly, one could expect that acylimidates would condense with amidines to produce compound V, which could be ring closed to the desired *s*-triazines. Actually, even under very mild reaction conditions, none of the open-chain precursors could be isolated. They dehydrated spontaneously at room temperature to *s*-triazines.

The amidine base is usually liberated from its salt *in situ* in a nonaqueous medium with sodium methoxide or sodium hydride, and acylimidate is then added. The resulting solution is allowed to stand at room temperature for 1 to 5 days. The scope of the reaction and the distribution of the products are summarized in Table I.

The most common by-products of the reaction are the amide R^2CONH_2 and the ester R^1CO_2R (or rather $R^1CO_2CH_3$ when methanol is present in the reaction medium). Both are formed presumably by the hydrolysis of the acylimidate with the water produced in the ring closure. Various dehydrating agents (such as anhydrous magnesium sulfate or Molecular Sieve) were added to the reaction media and azeotropic removal of water was attempted but in no case was the yield of the *s*-triazine significantly improved. This fact, together with previously mentioned inability to detect any of the open-chain intermediate V, indicates that the ring-closure step in the above reaction sequence is a very fast one. The yields of *s*-triazines are thus not expected to surpass 50%, which was found generally to be the case.

In addition to the formation of amides, R^2CONH_2, by hydrolytic cleavage of the imino group of the acylimidate, some less expected cleavage of the ether bond also occurred. Indeed, dipropionimide, $(C_2H_5CO)_2NH$,

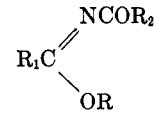


(6) H. L. Wheeler and P. T. Walden, *Am. Chem. J.*, **18**, 129 (1897); **20**, 568 (1898); H. L. Wheeler, P. T. Walden, and H. F. Metcalf, *ibid.*, **20**, 64 (1898).

(7) See the recent review by R. Roger and D. G. Neilson [*Chem. Rev.*, **61**, 204 (1961)].

TABLE II

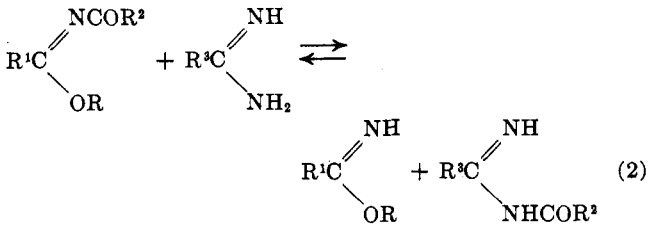
ACYLIMIDATES



							Calcd., %			Found, %		
R_1	R_2	R	% yield	B.p., °C. (mm.)	n_D (temp., °C.)	Formula	C	H	N	C	H	N
Et	Et	*i*-Pr	88.0	78–80 (15)	1.4320 (29)	$C_9H_{17}NO_2$	63.13	10.01	8.18	63.11	10.20	7.94
Et	Me	*i*-Pr	73.8	63 (10)	1.4295 (27)	$C_8H_{15}NO_2$	61.10	9.62	8.91	61.54	9.30	8.94
Et	CH=CHPh	*i*-Pr	83.1	121.5 (0.2)	1.6215 (28)	$C_{15}H_{19}NO_2$	73.43	7.81	5.71	73.37	8.12	6.14
Et	Ph	*i*-Pr	59.0	99 (0.2)	1.5140 (31)	$C_{13}H_{17}NO_2$	71.20	7.82	6.39	70.89	7.64	6.65
Ph	Et	Me	76.0	158 (22)	1.5290 (29)	$C_{11}H_{13}NO_2$	69.10	6.85	7.33	69.06	7.03	7.28

was isolated from a sample of IV ($R^1 = R^2 = C_2H_5$) which was exposed to atmospheric moisture. The amide by-products could in most cases be separated from the *s*-triazines by a simple filtration through alumina. The ester by-products were usually eliminated in the forerun of the distillation of the triazines.

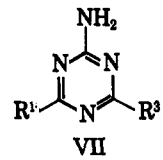
Table I shows a number of *s*-triazines, formed in smaller quantities, which were usually of the type 2,4-di-R^1-6-mono-R^2- or 2,4-di-R^2-6-mono-R^1-*s*-triazine. Their formation can be rationalized as being due to transacylation of the acylimidate with the amidine and regeneration of the original imidate. The latter can



(2)

now trimerize or cotrimerize with the amidine, to produce various *s*-triazines.[3] The nature of the by-product triazines will vary, however, with the starting materials. Fortunately, the present method allows some flexibility in selecting the one of the two or three permutations of the groups R^1, R^2, and R^3 in eq. 1 which will result in more easily separable by-product.

Amino-*s*-triazines are also found among the by-products of some of the reactions (expt. 2–5). They correspond formally to a replacement of the acyl substituent R^2 by an NH_2 group giving rise to VII. Although



VII

free ammonia would be produced in the copolymerization of imidates with amidines,[3d] the relatively high yields of the aminotriazines isolated (27–38%) indicate that they are formed by a direct condensation of two molecules of O-methylisourea (or guanidine) with one molecule of the original imidate (re-formed as shown in eq. 2).

The main purpose of the work presented here is to establish the scope of the reaction. Although only a limited effort was devoted to the study of reaction conditions, it was found that the yields of the desired *s*-triazines are favored by a less polar medium. Thus, the yield of 2-ethyl-4-methyl-6-styryl-*s*-triazine is increased from 28 to 53% when an ether–methanol solvent mixture is replaced with *t*-butanol (Table I, expt. 1a and 1b). It was also found that raising the reaction temperature had no beneficial effect on the yields of triazines VI.

Comparison of expt. 6 with expt. 8 (Table I) and of expt. 7 with expt. 9 brings out another benefit which can be derived from the flexibility of choice in the starting materials. The yields of the desired triazines (VIf and VIg) are low when R^2 is an aryl group (as in expt. 6 and 7). By changing R^1 and R^2 around and thus making group R^2 aliphatic, the yields of the same *s*-triazines are markedly improved, and those of by-products are reduced (expt. 8 and 9).

Experimental[8]

Acylimidates (IV). General Procedure.—A solution of 0.3 mole of acyl chloride in 50 ml. of methylene chloride was added dropwise over a period of 30 min. to a stirred solution of 0.3 mole of an imidate base and of 0.33 mole of triethylamine in 300 ml. of methylene chloride, kept below 0°. Stirring was continued for about 20 hr. at room temperature, the precipitated solid was filtered, solvent was removed, and the residue was redissolved in 300 ml. of pentane. Additional solid was separated, solvent was removed, and the residual oil was fractionally distilled. The individual acylimidates are listed in Table II.

***s*-Triazines.**—Some of the work-up procedures described below are aimed only at a fairly simple isolation of one product. Some others illustrate a more thorough work-up with the purpose of identifying all the by-products.

2-Ethyl-4-methyl-6-styryl-*s*-triazine (VIa). A. Best Procedure.—To a stirred solution of 5.2 g. (0.055 mole) of acetamidine hydrochloride in 75 ml. of *t*-butyl alcohol, 1.3 g. (0.055 mole) of sodium hydride in a mineral oil suspension was added at 35°. When hydrogen evolution had subsided, 12.25 g. (0.05 mole) of isopropyl N-cinnamoylpropionimidate was added and the mixture was allowed to stand 4 days at room temperature. The mixture was diluted with pentane, the solid was filtered, and the filtrate was evaporated. Distillation gave, after a small forerun, 6.0 g. (53.3%) of 2-ethyl-4-methyl-6-styryl-*s*-triazine: b.p. 125° (0.2 mm.); $n^{28}D$ 1.6215; λ_{max}^{EtOH} 224 mμ (ε 22,500) and 311 mμ (ε 34,000); and infrared absorption, 1640 (C=C), 1525 (triazine ring stretching), 875, 821, 749, and 690 cm.$^{-1}$.

Anal. Calcd. for $C_{14}H_{15}N_3$: C, 74.63; H, 6.71; N, 18.65. Found: C, 74.56; H, 7.12; N, 18.42.

B. With Isolation of By-products.—A solution of acetamidine in 70 ml. of methanol was prepared from 10.4 g. (0.11 mole) of its hydrochloride and from sodium methoxide (from 2.53 g., 0.11 mole, of sodium). It was diluted with 200 ml. of ether, 24.53 g. (0.1 mole) of isopropyl N-cinnamoylpropionimidate was added,

(8) All melting points are corrected. The infrared spectra were determined with a Perkin-Elmer Infracord spectrophotometer as liquid film, or, in case of solid, as a Nujol mineral oil mull. Ultraviolet spectra were determined on a Cary Model 12 ultraviolet spectrophotometer. The distilled products were analyzed for individual components by gas chromatography with a F and M Model 500 instrument using a 6-ft. 20% Carbowax 20,000 (on 60–80 Chromosorb W firebrick) column, or a 6-ft. silicone grease (on Chromosorb W firebrick) column, both obtained from F and M Scientific Corp. In some cases, analytically pure samples of individual components were secured also by g.l.c. separation.

and the mixture was allowed to stand at room temperature for 3 days. After filtration, the solvents were removed and the residue was extracted with hot ether. The extract was freed from solvent and the residue was re-extracted with hot pentane. The pentane-insoluble oil was shown by g.l.c. analysis to contain 1.45 g. (by calculation, 9.9% of theory) of cinnamide, which was further identified by infrared spectra and mixture melting point with an authentic sample.

The pentane extract was concentrated and adsorbed on 120 g. of alumina, and the column was eluted with 3600 ml. of pentane. The solvent was removed, and the residue was distilled, yielding 7.24 g. of oil. A g.l.c. analysis showed it to be composed (by calculation) of 6.31 g. (28.0%) of the *s*-triazine and 1.29 g. (7.95%) of methyl cinnamate (identified with an authentic sample through infrared spectrum and retention time on g.l.c.).

2-Ethyl-4-methoxy-6-styryl-*s*-triazine (VIb).—A solution of 12.15 g. (0.11 mole) of O-methylisourea hydrochloride in 40 ml. of methanol was added dropwise at 10° to a stirred solution of sodium methoxide (from 2.53 g., 0.11 mole, of sodium) in 60 ml. of methanol. To this solution 24.53 g. (0.1 mole) of isopropyl N-cinnamoylpropionimidate was added and the mixture was allowed to stand at room temperature for 3 days. Sodium chloride was filtered and the filtrate was evaporated to dryness. The residue was extracted with pentane leaving behind a solid A (see below). The pentane extract gave on evaporation 11.5 g. of an oil. Distillation up to b.p. 122° (10 mm.) yielded 2.66 g. of a liquid which was calculated by g.l.c. analysis to contain (i) 0.038 g. (0.23% over-all yield) of triethyl-*s*-triazine; (ii) 0.386 g. (2.31%) of 2,4-diethyl-6-methoxy-*s*-triazine; (iii) 0.391 g. (2.32%) of 2-ethyl-4,6-dimethoxy-*s*-triazine),[9] and two unidentified components.

The residue of the distillation (7.8 g.) was dissolved in a small volume of pentane, adsorbed on a 9.0 × 5.0 cm. alumina column and eluted first with pentane, and then with 9:1 pentane–ether mixture. After removal of solvent, crystallization from pentane gave 2-ethyl-4-methoxy-6-styryl-*s*-triazine (3.76 g., 15.6%) as pale yellow rosettes of needles: m.p. 52–52.5°; λ_{max} 226 mμ (ε 12,000) and 310 mμ (ε 26,000); and infrared absorption, 1625 (C=C), 1550 (shoulder), 1520 (triazine ring stretching), 873, 826, 755, 707, and 678 cm.$^{-1}$ (*cf.* the 4-methyl analog, above).

Anal. Calcd. for $C_{14}H_{15}N_3O$: C, 69.69; H, 6.27; N, 17.42. Found: C, 69.90; H, 6.41; N, 17.70.

The pentane-insoluble solid A was heated with benzene and the mixture was filtered. The insoluble solid (2.95 g.), m.p. 146–147°, was identified as cinnamide (mixture melting point, infrared spectra). The benzene mother liquor was concentrated and adsorbed on an alumina column. Elution with benzene containing up to 20% of methylene chloride gave, upon removal of solvent and crystallization, 3.1 g. of 2-amino-4-ethyl-6-methoxy-*s*-triazine as rhombic plates (from methylene chloride) or as rectangular prisms (from ether): m.p. 150.4–150.8° (both); and infrared absorption, 3320, 3180 (NH_2), 1640, 1545, 1510 (shoulder) (triazine ring), 1065, 1050, 1025, 952, 924, 828, and 800 cm.$^{-1}$.

Anal. Calcd. for $C_6H_{10}N_4O$: C, 46.74; H, 6.54; N, 36.34. Found: C, 46.89; H, 7.00; N, 36.24.

Further elution with methylene chloride gave a solid which upon crystallization from methylene chloride afforded 1.1 g. of a polymorph of 2-amino-4-ethyl-6-methoxy-*s*-triazine as microcrystals, m.p. 150.7–151.4°, differing mostly in infrared absorption: it lacked the 1065-cm.$^{-1}$ band and showed additional peaks at 1090 and 990 cm.$^{-1}$. Mixture melting points and spectra in solution proved the chemical identity of both forms.

Final elution of the column with methanol yielded an additional 4.9 g. of cinnamide (total yield, 53.4%).

2-Amino-4-ethyl-6-styryl-*s*-triazine (VIc).—Isopropyl N-cinnamoylpropionimidate (11.0 g., 0.045 mole) was added in portions to a stirred suspension of 5.35 g. (0.09 mole) of guanidine base in 20 ml. of *t*-butyl alcohol, with occasional external cooling. The resulting solution was kept at room temperature for 20 hr. Filtration gave 2.4 g. (38.3% theory) of 2,4-diamino-6-ethyl-*s*-triazine,[11] which after crystallization from ethanol sublimed at 225°: λ_{max} 256 mμ (ε 3600); and infrared absorption, 3320, 3150 (NH_2), 1660, 1640, 1535 (triazine ring), 1018, 985, 935, and 830 cm.$^{-1}$.

Anal. Calcd. for $C_5H_9N_5$: C, 43.15; H, 6.52; N, 50.32. Found: C, 43.19; H, 6.92; N, 50.39.

The filtrate was evaporated to dryness; the residue was dissolved in methylene chloride and extracted with 2 *N* sulfuric acid. Removal of solvent from the organic phase and crystallization of the residue from ether gave 2.4 g. (39.1%) of cinamide. The aqueous phase was made alkaline and extracted with methylene chloride; the dried extracts were evaporated. Fractional crystallization of the residue from pentane gave 2.76 g. (27.1% yield) of 2-amino-4-ethyl-6-styryl-*s*-triazine in colorless needles: m.p. 122–123°; λ_{max} 300 mμ (ε 29,000); and infrared absorption, 3310, 3150 (NH_2), 1660, 1640, 1540 (triazine ring), 990, 877, 830, 757, 709, and 685 cm.$^{-1}$.

Anal. Calcd. for $C_{13}H_{14}N_4$: C, 69.01; H, 6.24; N, 24.77. Found: C, 68.98; H, 6.12; N, 24.72.

In other experiments, a polymorph of this triazine was isolated, m.p. 112°. Both forms showed identical infrared absorption in carbon tetrachloride solution.

2,4-Diethyl-6-methoxy-*s*-triazine (VId).—A solution of 40.65 g. (0.165 mole) of O-methylisourea *p*-toluenesulfonate[12] in 50 ml. of methanol was added with stirring to a solution of sodium methoxide (from 3.80 g., 0.165 mole, of sodium) in 75 ml. of methanol. Anhydrous ether (500 ml.) was added, inorganic salts were filtered, and to the filtrate was added 25.7 g. (0.15 mole) of isopropyl N-propionylpropionimidate. The solution was allowed to stand 72 hr. at room temperature. The solvent was removed through 1-ft. Fenske column, and the residue was warmed with 150 ml. of pentane which caused a precipitation of a solid and of an oil. Filtration gave 7.8 g. (33.8%) of 2-amino-4-ethyl-5-methoxy-*s*-triazine, m.p. 150–151°, identical with the by-product isolated above. In the filtrate the oil crystallized to give 4.6 g. (21.1% yield based on a potential 2 equiv.) of propionamide, m.p. 78°, identified by infrared absorption and mixture melting point. The pentane solution was freed of solvent, fractionated through a 1-ft. Fenske column giving (i) 3.4 g. of a liquid, b.p. 87–96° (15 mm.), and containing (by g.l.c. analysis) 34.8% of triethyl-*s*-triazine and 61.5% of 2,4-diethyl-6-methoxy-*s*-triazine; (ii) 2.73 g. of 97.4% pure 2,4-diethyl-6-methoxy-*s*-triazine, b.p. 100° (15 mm.); and (iii) 5.79 g. of a mixture of the latter with 2-ethyl-4,6-dimethoxy-*s*-triazine. A g.l.c. analysis of the total distillate[9] indicated the following over-all yields: 8.92 g. (35.5%) of 2,4-diethyl-6-methoxy-*s*-triazine, 1.25 g. (7.58%) of triethyl-*s*-triazine, and 1.61 g. (6.34%) of 2-ethyl-4,6-dimethoxy-*s*-triazine.

2-Ethyl-4-methyl-6-methoxy-*s*-triazine (VIe).—In the manner described above, 31.44 g. (0.2 mole) of isopropyl N-acetylpropionimidate and O-methylisourea (from 22.1 g., 0.2 mole, of hydrochloride and 4.6 g. sodium) were allowed to react for a period of 5 days in a mixture of 125 ml. of methanol and 300 ml. of ether. Removal of solvent, extraction of the residue with pentane, and distillation of the extract gave 23.34 g. of liquid, b.p. 88–120° (13 mm.), the composition of which is given in Table I, expt. 5. Fractionation through a 3-ft. Snyder column gave 4.6 g. of pure 2-ethyl-4-methyl-6-methoxy-*s*-triazine: b.p. 111° (17 mm.); $n^{25}D$ 1.4820; and infrared absorption, 1552 and 1530 (triazine ring stretching), 922, and 828 cm.$^{-1}$ (*cf.* 2,4-diethyl-6-methoxy-*s*-triazine).[10]

Anal. Calcd. for $C_7H_{11}N_3O$: C, 54.87; H, 7.24; N, 27.43. Found: C, 54.71; H, 7.36; N, 27.48.

2-Ethyl-4-methylthio-6-phenyl-*s*-triazine (VIf).—Methyl N-propionylbenzimidate (19.1 g., 0.1 mole) was added to a solution of S-methylisothiourea (prepared from 12.65 g., 0.11 mole, of the hydrochloride and 5.94 g., 0.11 mole, of sodium methoxide) in 100 ml. of methanol and 350 ml. of anhydrous ether. After stirring at room temperature for 3 days the mixture was filtered, the filtrate was evaporated to dryness, and the residue was extracted with pentane. The concentrated extract was adsorbed on 12 × 4 cm. alumina column and eluted with 2700 ml. of pentane and then with 1500 ml. of a 1:4 ether–pentane mixture. After removal of solvent the pentane eluate gave upon distillation a small forerun (*ca.* 0.7 g., 5.1%) of methyl benzoate (identified through infrared spectrum and g.l.c. retention time), and 5.8 g. (25.0% theory) of 2-ethyl-4-methylthio-6-phenyl-*s*-triazine, b.p. 135° (0.3 mm.), $n^{27}D$ 1.6110, which crystallized in needles: m.p. 31–33°; λ_{max} 263 mμ (ε 34,700); and infrared absorption, 1615 and 1575 (w), 1520 and 1500 (triazine ring), 978, 884, 843, 832, 798, 758, and 695 cm.$^{-1}$.

Anal. Calcd. for $C_{12}H_{13}N_3S$: C, 62.30; H, 5.66; N, 18.17; S, 13.87. Found: C, 62.51; H, 5.58; N, 18.13; S, 13.67.

(9) Analyses of the mixtures of the same three *s*-triazines by g.l.c. were reported in part II: *cf.* ref. 10.

(10) Part II: H. Bader, E. R. Ruckel, F. X. Markley, S. G. Santangelo, and P. Schickedantz, *J. Org. Chem.*, **30**, 702 (1965).

(11) C. Haaf [*J. prakt. Chem.*, (2) **43**, 75 (1891)] gives melting point above 300°.

(12) J. W. Janus, *J. Chem. Soc.*, 3551 (1955).

Evaporation of the ether–pentane eluate and distillation of the residue gave 1.4 g. (6.5%) of 2-ethyl-4-methoxy-6-phenyl-*s*-triazine, b.p. 100–103° (0.1 mm.), $n^{31}D$ 1.5700, which crystallized on standing in needles: m.p. 28.5–30.5°; λ_{max} 263 mμ (ε 20,500); and infrared absorption, 1545 (triazine ring), 1350, 1035, 1055, 928, and 839 (common to 2,4-diethyl-6-methoxy-*s*-triazine[10]) and 781, 730, and 687 cm.$^{-1}$ (phenyl ring).

Anal. Calcd. for $C_{12}H_{13}N_3O$: C, 66.96; H, 6.09; N, 19.53; O, 7.42. Found: C, 66.59; H, 5.94; N, 19.65; O, 7.57.

2 Ethyl 4-methyl-6-phenyl-*s*-triazine (VIg).—Reaction of 19.1 g. of methyl N-propionylbenzimidate with acetamidine (from 10.4 g., 0.11 mole, of hydrochloride) was performed in a manner exactly similar to that of the previous experiment and was followed by a similar work-up. The pentane extract was adsorbed on 150 g. of alumina and eluted with 4500 ml. of pentane. Distillation of the residue after removal of pentane gave 10.0 g. of oil, b.p. 88° (0.1 mm.), which was shown by g.l.c. analysis to contain 9.42 g. (by calculation, 47.6% yield) of 2-ethyl-4-methyl-6-phenyl-*s*-triazine, 0.41 g. (1.9%) of 2,4-diethyl-6-phenyl-*s*-triazine, and 0.16 g. (1.2%) of methyl benzoate. The middle cut of the distillation, $n^{30}D$ 1.5700, 97% content of the main product, was used for analysis: λ_{max} 263 mμ (ε 21,500); and infrared absorption, 1540 (triazine ring), 930, 867, 797, 752, and 695 cm.$^{-1}$ (phenyl ring).

Anal. Calcd. for $C_{12}H_{13}N_3$: C, 72.33; H, 6.57; N, 21.09. Found: C, 72.33; H, 6.58; N, 20.80.

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Syntheses and Reactions of 5-Alkyl-4-amino-3-hydrazino-*s*-triazoles

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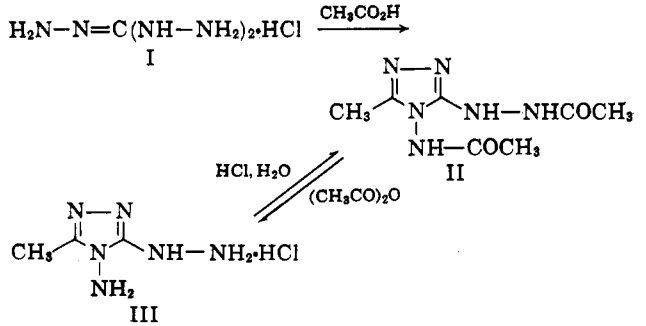
Triaminoguanidine hydrochloride was treated with acetic and propionic acids to yield 5-alkyl-4-amino-3-hydrazino-*s*-triazole hydrochlorides. An organic azide was prepared from the triazole and thermally decomposed after treatment with benzaldehyde to yield 1H-3-methyl-2-phenyl-*s*-triazolo[3,2-*c*]-*s*-triazole. Other reactions of the triazoles with benzaldehyde, acetic anhydride, and 2,4-pentanedione are described.

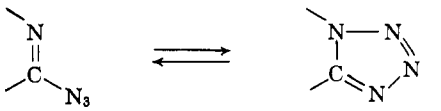
Although a number of methods are available for the preparation of *s*-triazoles, few are amenable for the synthesis of 4H-3-hydrazino-*s*-triazole derivatives. These compounds have been obtained by the reduction of nitroaminotriazoles,[1] the hydrolysis of semicarbazidotriazole,[2] and the reaction of N,N′-dithiocarbamylhydrazine[3] with hydrazine. Alternatively, triaminoguanidine hydrochloride (I) has been reported[4] to react with formic acid to yield a *s*-triazole derivative, whereas, I with acetic acid yielded only a resinous product. We have reinvestigated the reaction of triaminoguanidine hydrochloride with acetic acid and with propionic acid and have obtained the 5-alkyl-4-amino-3-hydrazino-*s*-triazole hydrochlorides in good yield. The syntheses and reactions of these triazoles are described in this report.

As reported by earlier workers,[4] refluxing I in acetic acid and removal of the solvent produced a viscous, resinous residue. From this residue, a moderate yield of 4-acetamido-3-acethydrazino-5-methyl-*s*-triazole hydrochloride (II) was isolated when extreme care was taken to remove the last traces of volatiles. However, when the viscous residue was refluxed in dilute hydrochloric acid, an excellent yield of 4-amino-3-hydrazino-5-methyl-*s*-triazole hydrochloride (III) was obtained. The difficulties encountered in the isolation of the diacetyl derivative II were presumably due to the formation of a mixture of triazoles acetylated to varying extents, which upon acid hydrolysis yielded a crystalline hydrochloride.



The present study was extended to propionic and benzoic acid. Although the latter acid failed to yield the cyclized product, propionic acid readily gave 4-amino-5-ethyl-3-hydrazino-*s*-triazole hydrochloride (IV) following the procedure for acetic acid. The 4-benzylidenehydrazino derivative was obtained by the reaction of IV with benzaldehyde.

The 3-hydrazino group of the triazole III was converted to an azido group by treatment with one equivalent of nitrous acid. Subsequent reaction of this azido compound with benzaldehyde yielded 3-azido-4-benzylideneamino-5-methyl-*s*-triazole (V). Although the azido group attached to the carbon atom of the azomethine linkage can readily undergo ring closure to form a tetrazole, the infrared spectrum of V taken on a potassium bromide wafer exhibited an intense band at 2150 cm.$^{-1}$ characteristic of azides.[5]



Compound V, when heated in chlorobenzene, smoothly liberated 1 mole of nitrogen. The azene (univalent, uncharged nitrogen) intermediate[6] thus

(1) (a) W. Manchot and R. Noll, *Ann.*, **343**, 1 (1905); (b) W. Manchot, *Ber.*, **43**, 1312 (1910); (c) R. A. Henry, S. Skolnik, and G. B. L. Smith, *J. Am. Chem. Soc.*, **75**, 955 (1953); (d) E. Lieber, S. Schiff, R. A. Henry, and W. Finnegan, *J. Org. Chem.*, **18**, 218 (1953).

(2) H. Gehlen and F. Lemme, *Naturwissenschaften*, **50**, 645 (1963).

(3) E. Hoggarth, *J. Chem. Soc.*, 4817 (1952).

(4) C. F. Kröger, G. Etzold, and H. Beyer, *Ann.*, **664**, 146 (1963).

(5) L. J. Bellamy, "The Infrared Spectra of Complex Molecules," John Wiley and Sons, Inc., New York, N. Y., 1954, Chapter 15.

(6) For a review of univalent, uncharged nitrogens, see R. A. Abramovitch and B. A. Davis, *Chem. Rev.*, **64**, 149 (1964).