diamino-*s*-triazine (IV), 11 g. (0.135 mole) of dimethylamine hydrochloride and 1.4 g. (0.010 mole) of zinc chloride. The mixture was fused and maintained at 220–240° for 1 hr. with stirring. After cooling, 70 ml. of cold water was added and filtered. The filtrate was extracted with 100 ml. of Skellysolve A which upon evaporation yielded 0.112 g. of material, m.p. 40.5–42°. The material from two such runs was combined, dissolved in 75 ml. of Skellysolve A, insoluble material removed by filtration, and the solid was chromatographed on an alumina column. The column was eluted with pure Skellysolve A; 50-ml. fractions were taken. The materials obtained from the fourth and fifth eluates (m.p. 42–43°) were combined and recrystallized from Skellysolve A, m.p. 45–46°, and a mixed melting point with an authentic sample was not depressed, m.p. 44.5–45.5°.

4,6-Di-(monomethylamino)-*s*-triazine from 4,6-Diamino-2-methyl-*s*-triazine.—This compound was prepared by essentially the same procedure described by Thurston, m.p. 255–256°.[16]

4,6-Diamino-2-methoxyethyl-*s*-triazine (III, R′ = $CH_2CH_2OCH_3$).—A solution of 10 g. (0.1 mole) of biguanide and 9 g. (0.1 mole) of methyl acrylate in 150 ml. of absolute methanol were refluxed for 1.5 hr. On cooling, 7 g. of crude product, m.p. 205–209°, was obtained. After digesting this product with aqueous methanol at steam-bath temperature for 0.5 hr., insoluble material was removed by filtration and the solution cooled. Crystalline material, 6.5 g., was obtained, melting at 210–211°. Concentration of the original filtrate yielded another 2 g. of product; total yield, 8.5 g. (51%).

Anal. Calcd. for $C_6H_{11}N_5O$: C, 42.59; H, 6.55; N, 41.40; O, 9.46. Found: C, 42.58; H, 6.49; N, 41.32; O, 9.61.

Acknowledgments.—We wish to gratefully acknowledge the support of this work by a Grant-in-aid from Eli Lilly and Company. We also thank the American Cyanamid Company for their generous gifts of phenylbiguanide and biguanide.

BROOKLYN 1, NEW YORK

[CONTRIBUTION FROM THE OHIO STATE UNIVERSITY RESEARCH FOUNDATION]

Triazines. XVIII. The Reaction of Aliphatic Diazocompounds with Chloro-s-triazines[1,2]

BY CHRISTOPH GRUNDMANN AND EHRENFRIED KOBER

RECEIVED JUNE 6, 1956

Di- and trichloro-*s*-triazines react with diazomethane and its homologs to yield α-diazoalkyl-substituted triazines. Usually only one chlorine atom is substituted. The other chlorine atoms can be replaced by alkoxy- or amino groups without affecting the diazo group. On the basis of the reactivity of the diazo group toward halogens and acids, the α-diazoalkyl-*s*-triazines resemble derivatives of diazoacetic acid.

In many of their properties the cyanuric trihalides, or 2,4,6-trihalogeno-1,3,5-triazines, resemble the halogenides of organic acids. Because the latter compounds react easily with diazomethane and its homologs to give diazoketones, a reaction of halogeno-triazines and aliphatic diazo compounds seemed possible.

Cyanuric chloride (I) reacts readily with two moles of diazomethane in ethereal solution at room temperature, liberating elementary nitrogen to form a well crystallized yellow compound, 2-diazomethyl-4,6-dichloro-1,3,5-triazine (II). The possible isomeric structures of a triazolo-triazine (IIIa and IIIb) seem to be definitely excluded by the reactions of II which are quite analogous to those of the known aliphatic diazo compounds. Furthermore the infrared spectrum of this and other diazosubstituted triazines displays the characteristic band (at 2120 cm.$^{-1}$) of the aliphatic diazo compounds.

With a large excess of diazomethane and prolonged reaction time, the second chlorine atom of the cyanuric chloride also is substituted to some extent. Because of its instability, however, we were unable to prepare the expected 2,4-bis-diazomethyl-6-chloro-triazine (IV) in a pure state. There was never any indication of the reaction of the third chlorine atom of I.

Other chloro-*s*-triazines which react as well with diazomethane as does cyanuric chloride are 4,6-dichloro-2-methyl-*s*-triazine (V) and 4,6-dichloro-2-phenyl-*s*-triazine (VI). They give the expected compounds, 6-chloro-4-diazomethyl-2-methyl-*s*-triazine (VII) and 6-chloro-4-diazomethyl-2-phenyl-*s*-triazine (VIII). 6-Chloro-2,4-diphenyl-*s*-triazine (IX) does not react. With 2,4-bis-trichloromethyl-6-chloro-*s*-triazine[3] (X), in which the chlorine attached to the nucleus is much more mobile than in IX, the reaction apparently is not only confined to the 6-position but also includes the trichloromethyl groups, thus complicating the picture.

On the other hand, diazomethane can be replaced by homologs. For instance, from I and diazoethane 2,1′-diazoethyl-4,6-dichloro-*s*-triazine (XI) is obtained; ethyl diazoacetate yields 4,6-dichloro-*s*-triazinyl-2-diazoacetic acid ethyl ester (XII). The latter reaction requires elevated temperatures and prolonged reaction time, illustrating the lower degree of reactivity of the diazoester compared to the diazoalkanes. It is not surprising, then, that the more stable diazoketones, like ω-diazoacetophenone, do not react with cyanuric chloride.

The chlorine atoms in the 4- and 6-positions of the diazomethyl substituted triazines can be replaced without alteration of the diazo group by alkoxy groups, by thioalkyl groups and by amino groups. Using this method, 2-diazomethyl-4,6-dimethoxy-*s*-triazine (XIII) and 2-diazomethyl-4,6-diethoxy-*s*-triazine (XIV) were prepared. Since the presence of the reactive chlorine atoms in the original reaction products, such as II, often involves complications, many of the reactions of the

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(1) This article is based on work performed under Project 116-B of The Ohio State University Research Foundation sponsored by the Olin Mathieson Chemical Corporation, New York, N. Y.

(2) Preceding communication, Ch. Grundmann and E. Kober, *J. Org. Chem.*, **21**, 1392 (1956).

(3) H. Schroeder and Ch. Grundmann, THIS JOURNAL, **78**, 2447 (1956).

diazo-substituted triazines were studied with 2-diazomethyl-4,6-dimethoxy-*s*-triazine (XIII), which reacts more uniformly.

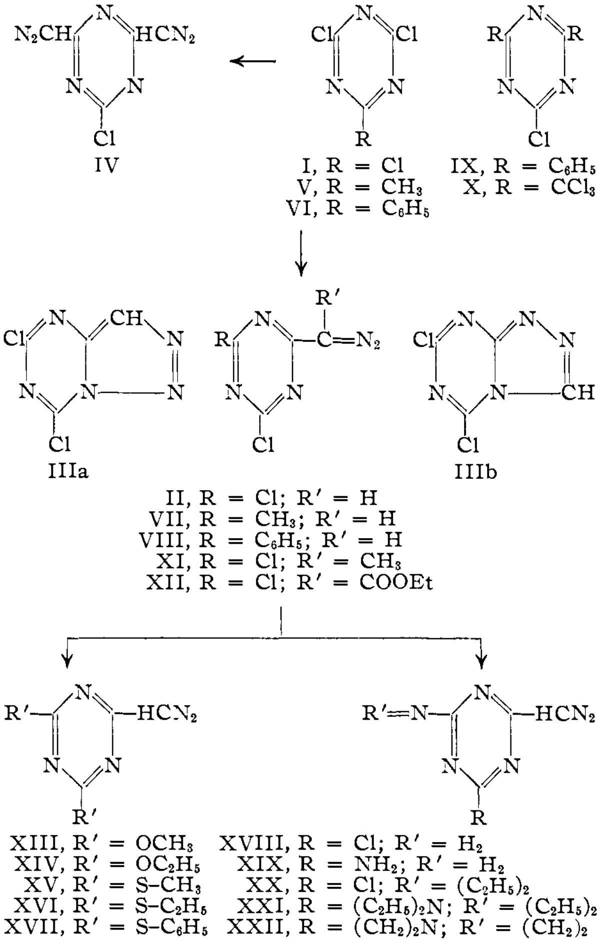
With methyl, ethyl and phenyl mercaptans the corresponding 4,6-substituted 2-diazomethyltriazines XV, XVI and XVII were obtained from II, but only when the exact stoichiometric amount of the mercaptan was employed.

Amino derivatives prepared from II include 4-amino-6-chloro-2-diazomethyl-*s*-triazine (XVIII), 4,6-diamino-2-diazomethyl-*s*-triazine (XIX), 6-chloro-2-diazomethyl-4-diethylamino-*s*-triazine (XX), 4,6-bis-diethylamino-2-diazomethyl-*s*-triazine (XXI) and 4,6-aziridino-2-diazomethyl-*s*-triazine (XXII). A naturally occurring aliphatic diazo compound, *O*-diazoacetyl-*l*-serine (azaserine), has among its interesting properties a marked cytostatic activity.[4] Compounds of type XXII may be of certain interest in this respect since they contain the active ethylene-imino group and the aliphatic diazo group in the same molecule.

The reactions discussed above are summarized in Chart I.

CHART I

FORMATION OF DIAZOALKYL-*s*-TRIAZINES AND REACTIONS NOT INVOLVING THE DIAZO GROUP



IV

I, R = Cl
V, R = CH_3
VI, R = C_6H_5

IX, R = C_6H_5
X, R = CCl_3

IIIa

IIIb

II, R = Cl; R′ = H
VII, R = CH_3; R′ = H
VIII, R = C_6H_5; R′ = H
XI, R = Cl; R′ = CH_3
XII, R = Cl; R′ = COOEt

XIII, R′ = OCH_3
XIV, R′ = OC_2H_5
XV, R′ = S-CH_3
XVI, R′ = S-C_2H_5
XVII, R′ = S-C_6H_5

XVIII, R = Cl; R′ = H_2
XIX, R = NH_2; R′ = H_2
XX, R = Cl; R′ = $(C_2H_5)_2$
XXI, R = $(C_2H_5)_2N$; R′ = $(C_2H_5)_2$
XXII, R = $(CH_2)_2N$; R′ = $(CH_2)_2$

The diazo group in all the α-diazoalkyltriazine derivatives investigated undergoes the reactions characteristic of aliphatic diazo compounds. The reactivity of these compounds, however, is not as great as that of the true diazoalkanes. Instead, they are comparable to the α-diazocarbonyl compounds. In fact, the α-diazoalkyltriazine derivatives structurally resemble the carbonyl compounds when one considers the valency state of the carbon atom attached to the $C{=}N_2$ group. For example, the diazomethyltriazines may be considered as cyclic substituted amidines of diazoacetic acid.

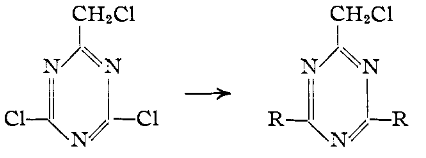
The reaction mechanism can thus be supposed to follow a course similar to that suggested by Huisgen[5] for the acyl chlorides.[5]

A diazo alkyl group, once formed, will tend to shift electrons into the triazine ring system and decrease the tendency of the C=N double bonds toward addition. It is therefore understandable that a second chlorine atom in the 4-position does not react as easily, especially if another electron-donating group is already present in the 6-position. Obviously the C=N bond of the triazine ring will not become activated if two strong electron donors are present in the 2- and 4-positions. This explains the inertness of such 6-chlorotriazines as IX against diazomethane.

The diazomethyl-*s*-triazines react normally at room temperature with halogens in an inert solvent like tetrachloromethane to give the expected dihalomethyl-*s*-triazines. A number of these compounds are presented in Table I.

Ethereal hydrogen chloride converts the diazomethyl-*s*-triazines into the corresponding chloromethyl compounds. However, in each case ether-insoluble by-products, the hydrochlorides of the corresponding chloromethyl-*s*-triazines, are obtained. If the starting material contains constituents attackable by hydrogen chloride, they too may be converted. For example, from XIII we isolated the hydrochloride of 2-chloromethyl-4,6-dihydroxy-*s*-triazine (XXIX), which indicates the cleavage of the two methoxy groups.

The chlorine in the chloromethyl group is much less mobile than that directly bound to the triazine ring. From 2-chloromethyl-4,6-dichloro-*s*-triazine (XXVII), using alcoholic ammonia, we obtained only the 2-chloromethyl-4,6-diamino-*s*-triazine (XXXIV) and, using sodium methoxide, 2-chloromethyl-4,6-dimethoxy-*s*-triazine (XXVIII) was obtained; *cf.* Table II, footnote *b*.



XXVII

XXVIII, R = OCH_3
XXXIV, R = NH_2

Dilute sulfuric acid converts the diazomethyl-*s*-triazines to the corresponding primary carbinols, whereas organic acids lead to good yields of the corresponding esters. A number of compounds obtained by the action of acids on the diazomethyl-*s*-triazines are presented in Table II.

Acknowledgment.—We are very much indebted to the Olin Mathieson Chemical Corporation for their generous support of this work. We further-

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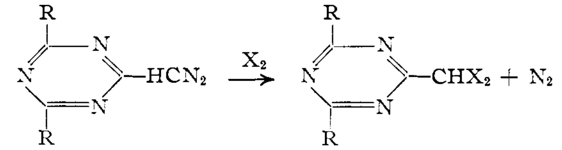
[4] S. Fusari, *et al.*, THIS JOURNAL, **76**, 2878, 2881 (1954).

[5] *Cf.* R. Huisgen, *Angew. Chem.*, **67**, 439 (1955).

TABLE I

DIHALOGENOMETHYL-*s*-TRIAZINES

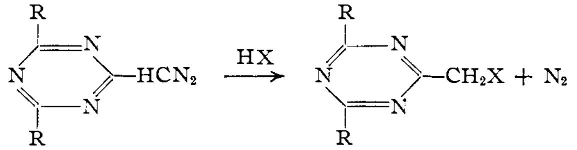


No.	X	R	B.p. °C.	B.p. Mm.	n^tD	*t*, °C.	Yield, %	Formula	Found C	Found H	Found N	Calcd. C	Calcd. H	Calcd. N
XXIII	Cl	Cl	78–82	0.05	1.5550	25	72.0	$C_4HCl_4N_3$	20.93 Cl, 60.52	0.76	17.63	20.63 Cl, 60.90	0.43	18.04
XXIV	I	Cl	89–91[a]		....		89.5	$C_4HCl_2I_2N_3$	Cl, 18.40			Cl, 17.10		
XXV	Cl	OCH_3	86–88	.045	1.5200	23	33.4	$C_6H_7Cl_2N_3O_2$	32.32 Cl, 31.25	3.26	19.10	32.16 Cl, 31.65	3.15	18.76
XXVI	Br	OCH_3	112–113	.017	1.5628	27	71.2	$C_6H_7Br_2N_3O_2$	Br, 51.03			Br, 51.07		

[a] M.p.; XXIV decomposes gradually at room temperature under liberation of iodine. Found: I, 56.48. Calcd.: I, 61.19.

TABLE II

REACTION PRODUCTS FROM DIAZOMETHYL-*s*-TRIAZINES AND ACIDS



No.	X	R	M.p., °C.	Yield, %	Formula	Found C	Found H	Found N	Found Cl	Calcd. C	Calcd. H	Calcd. N	Calcd. Ce
XXVII	Cl	Cl	36–37[a]	76	$C_4H_2Cl_3N_3$	24.19	1.29	21.58	53.08	24.21	1.01	21.18	53.60
XXVIII	Cl	OCH_3	58–58.5	27[b]	$C_6H_8ClN_3O_2$	37.98	4.39	22.11	18.58	38.01	4.25	22.16	18.70
XXIX	Cl	OH	218–220[c]	70[d]	$C_4H_5Cl_2N_3O_2$	23.97	3.48	20.89	35.62	24.24	2.55	21.23	35.81
XXX	OH	OCH_3	115–116	57	$C_6H_9N_3O_3$	41.99	5.27	24.54		42.10	5.30	24.55	
XXXI	$OOCCH_3$	OCH_3	44.5–45.5	74	$C_8H_{11}N_3O_4$	44.99	5.26	19.71		45.06	5.20	19.71	
XXXII	$OOCC_6H_5$	OCH_3	84–86	81	$C_{13}H_{13}N_3O_4$	56.86	4.71	15.15		56.42	4.76	15.27	
XXXIII	$OOCC_6H_4NH_2(p)$	$N(C_2H_5)_2$	88–89	88	$C_{19}H_{28}N_6O_2$	61.08	7.68	22.58		61.26	7.58	22.57	

[a] Allotropic form melts at 20.5°; b.p. 70–71° (0.05 mm.), $n^{38.5}$D 1.5461. [b] XXVIII was also obtained with 92% yield from XXVII by refluxing with two moles of sodium methoxide in methanol for 2 hr. [c] Isolated as the hydrochloride from XIII and HCl, besides XXVIII. [d] Crude product, see Experimental part.

more appreciate a gift of cyanuric chloride from Nilok Chemicals, Inc., Lockport, N. Y.

Experimental[6,7]

2-Diazomethyl-4,6-dichloro-*s*-triazine (II).—A solution of 44.3 g. of pure cyanuric chloride in 800 ml. of ether was slowly added with stirring to a solution, held at 0°, of approximately 23 g. of diazomethane in 1000 ml. of ether. The reaction mixture was allowed to stand for two days at room temperature and then filtered from a small amount of solid by-products. The ether was removed from the filtrate by distillation at room temperature under a slight vacuum. The resulting residue was extracted three times with 800, 500 and, finally, 300 ml. of hot ligroin.[8] After maintaining the extracts at a temperature of −25° for two days, yellow starlets crystallized (39.7 g., 87.5%), m.p. 110–111°. This product was sufficiently pure for most purposes. For final purification the crystals were sublimed in small amounts, under atmospheric pressure at 100–125°, yielding faint yellow, thin needles, m.p. 111.5–112.5°.

Anal. Calcd. for $C_4HCl_2N_5$: C, 25.29; H, 0.53; Cl, 37.32; N, 36.86. Found: C, 25.33; H, 0.59; Cl, 37.01; N, 36.70.

2,4-Bis-diazomethyl-6-chloro-*s*-triazine (IV).—This compound was formed from the above described reaction by using only one-third as much cyanuric chloride and allowing the reaction mixture to stand for seven days. Yellow crystals (0.8 g., m.p. 92–120° dec.) separated only from the first ligroin extract. Analysis revealed that these crystals were a mixture of approximately 50% of the monodiazomethyl compound II and the desired IV. Separation of this mixture by means of recrystallization or sublimation failed because the bis-diazo compound IV invariably decomposed during these operations with evolution of nitrogen.

Anal. Calcd. for a mixture of 50% $C_4HCl_2N_5$ and 50% of $C_5H_2ClN_7$: C, 28.00; H, 0.78; Cl, 27.72; N, 43.50. Found: C, 28.71; H, 1.55; Cl, 26.68; N, 42.81.

6-Chloro-4-diazomethyl-2-methyl-*s*-triazine (VII).—A solution of 24.6 g. of 4,6-dichloro-2-methyl-*s*-triazine[9] in 700 ml. of dry ether was slowly added with stirring to the solution of 14 g. of diazomethane in 600 ml. of dry ether at 0°. After standing for two days at room temperature, the solid by-products which formed were filtered off, the ether and excess diazomethane were removed by distillation and the resulting residue was extracted with 500 ml. of ligroin at room temperature.

The extract was kept at −25° for several days, whereupon a small amount of a yellow crystalline by-product precipitated, which was removed by filtration. After the filtrate was concentrated *in vacuo* to about 200 ml., a mixture of yellow needles and starlets crystallized upon storage at −25°. The crystals were filtered off and the needles and starlets separated by hand. The starlets proved to be unchanged starting material, while the needles (0.8 g.) were the desired diazo compound VII. After recrystallization from ligroin, very thin yellow needles were obtained, m.p. 89–90°.

Anal. Calcd. for $C_5H_4ClN_5$: C, 35.41; H, 2.37; Cl, 20.91. Found: C, 35.38; H, 2.27; Cl, 21.13.

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(6) All melting points were taken with the Fisher-Johns apparatus; microanalyses were by the Galbraith Laboratories, Knoxville, Tenn., and Spang Microanalytical Laboratory, Ann Arbor, Michigan.

(7) Care is recommended in working with large amounts of all these diazo compounds. All of them decompose rapidly when overheated, and in some cases, the decomposition was followed by a violent explosion. Crude material is usually more sensitive than purified. Whenever possible, it is recommended first to recrystallize before sublimation or distillation of these compounds.

(8) If not indicated otherwise, a fraction with a boiling range from 90–97° was used in this and the following experiments.

(9) W. Hentrich and M. Hardtmann, U. S. Patent 1,991,689.

6-Chloro-4-diazomethyl-2-phenyl-*s*-triazine (VIII).—Essentially the same procedure as described for II produced the diazotriazine VIII (8.85 g., 76.3%) from 11.3 g. of 4,6-dichloro-2-phenyl-*s*-triazine[10] in 700 ml. of ether and 11.5 g. of diazomethane in 500 ml. of ether. VIII crystallized from ligroin as yellow starlets, m.p. 107–109°.

Anal. Calcd. for $C_{10}H_6ClN_5$: C, 51.85; H, 2.61; Cl, 15.31; N, 30.24. Found: C, 52.11; H, 2.90; Cl, 15.01; N, 29.80.

2[1′-Diazoethyl]-4,6-dichloro-*s*-triazine (XI).—The reaction between cyanuric chloride (18.45 g.) and diazoethane (about 0.3 mole) was carried out essentially as described above for the preparation of II. The oily residue remaining after distilling off the ether was extracted twice, once with 750 and then with 500 ml. of boiling ligroin. After standing for one day at −20°, a yellow oil containing some crystals had separated from the extracts. The supernatant liquid was separated by decantation and evaporated *in vacuo* to a small volume. The diazotriazine XI (2.45 g.) crystallized in orange colored needles, m.p. 97–100°, after drying on a porous clay plate. From the aforementioned oil a further crop of 1.1 g. of XI was obtained by extraction with ligroin followed by treatment of this extract as described before; yellow needles, m.p. 100–101°, crystallized from ligroin.

Anal. Calcd. for $C_5H_3Cl_2N_5$: C, 29.43; H, 1.48; N, 34.33; Cl, 34.76. Found: C, 29.06; H, 1.73; N, 33.80; Cl, 35.46.

(4,6-Dichloro-*s*-triazinyl-2)-diazoacetic Acid Ethylester (XII).—A mixture of ethyl diazoacetate (0.066 mole) and cyanuric chloride (0.01 mole) in 40 ml. of ligroin was refluxed for 9 hr. After distilling off the solvent, the excess diazoacetate and the formed ethyl chloroacetate were removed *in vacuo*, raising the bath temperature gradually to 135° at 3.5 mm. A red oil remained which, after standing for several days at room temperature, partially crystallized. The crystals were dried on a porous clay plate. After several recrystallizations from ligroin, yellow needles (0.68 g.), m.p. 53–54°, were obtained.

Anal. Calcd. for $C_7H_5Cl_2N_5O_2$: C, 32.08; H, 1.92; Cl, 27.06; N, 26.73. Found: C, 32.39; H, 1.94; Cl, 27.00; N, 26.53.

2-Diazomethyl-4,6-dimethoxy-*s*-triazine (XIII).—A solution of 38 g. of 2-diazomethyl-4,6-dichloro-*s*-triazine (II) in 650 ml. of methanol was added slowly with stirring to a solution of 9.2 g. of sodium in 250 ml. of methanol at 0°. After standing for 24 hr., the reaction was completed by refluxing for 30 minutes. The formed sodium chloride was filtered off and the methanol removed from the filtrate by distillation, applying a slight vacuum at the end of the operation. The resulting residue was extracted with boiling ligroin (b.p. 60–70°), from which the diazotriazine XIII separated as yellow prisms (28.3 g., 78.4%) on cooling. The product could be further purified by vacuum sublimation (110–135° (0.015 mm.)), m.p. 105–106°.

Anal. Calcd. for $C_6H_7N_5O_2$: C, 39.78; H, 3.89; N, 38.67. Found: C, 39.82; H, 3.90; N, 38.94.

In an analogous manner, II was converted by sodium ethylate in ethanol with 70% yield into **2-diazomethyl-4,6-diethoxy-*s*-triazine (XIV)**; yellow prisms, m.p. 62.5°, were obtained from ligroin (b.p. 60–70°).

Anal. Calcd. for $C_8H_{11}N_5O_2$: C, 45.93; H, 5.30; N, 33.48. Found: C, 46.07; H, 5.30; N, 33.36.

4,6-Bis-thiomethyl-2-diazomethyl-*s*-triazine (XV).—Sodium (1.15 g.) was dissolved in 50 g. of methanethiol with stirring at a temperature between −20 and 0°. The excess of methanethiol was allowed to evaporate at room temperature and the solid residue suspended in 100 ml. of xylene, cooled to 0° and 4.75 g. of finely powdered II added with stirring. The reaction mixture was stirred for 10 hr. at room temperature and finally kept for 30 minutes between 50 and 60°. All operations were carried out under pure nitrogen. After filtering, the filtrate was freed from xylene by distillation in a vacuum at 50° bath temperature. The residue crystallized from ligroin in thin yellow needles (3.75 g., 70%) which soon turned violet on exposure to light; m.p. 112–115°.

Anal. Calcd. for $C_6H_7N_5S_2$: C, 33.79; H, 3.30; N, 32.84; S, 30.07. Found: C, 33.54; H, 3.10; N, 33.26; S, 30.14.

In an analogous manner, using ethanethiol instead of methanethiol, **4,6-bis-thioethyl-2-diazomethyl-*s*-triazine (XVI)** was obtained from II. The crude XVI remained as an orange colored oil, solidifying at 0° after distilling off the xylene. The compound could be recrystallized from petroleum ether (b.p. 30–40°), m.p. 34–35°.

Anal. Calcd. for $C_8H_{11}N_5S_2$: C, 39.81; H, 4.60; N, 29.03. Found: C, 39.82; H, 4.12; N, 28.88.

4,6-Bis-thiophenyl-2-diazomethyl-*s*-triazine (XVII).—A solution of sodium (1.15 g.) in benzenethiol (85 g.) was prepared by refluxing with stirring in an atmosphere of nitrogen. The excess of solvent was removed by vacuum distillation. After cooling, the solid residue was allowed to react as described before with 4.75 g. of II. The crude XVII (7.0 g., 83%) crystallized from ligroin in yellow needles, sensitive to light, m.p. 98–99°.

Anal. Calcd. for $C_{16}H_{11}N_5S_2$: C, 56.95; H, 3.29; N, 20.76; S, 19.00. Found: C, 56.86; H, 3.48; N, 20.73; S, 19.00.

4-Amino-6-chloro-2-diazomethyl-*s*-triazine (XVIII).—Ammonia was passed for 2 hr. through a refluxing solution of 4 g. of 2-diazomethyl-4,6-dichloro-*s*-triazine (II) in 100 ml. of dry acetonitrile. After cooling down to room temperature, the solution was filtered from the ammonium chloride and evaporated *in vacuo* to dryness. The solid residue (2.4 g.) was extracted with ether, the combined ethereal extracts washed three times with water and dried over sodium sulfate. After removal of the ether *in vacuo* there remained 1.7 g. (60.8%) of 2-amino-6-chloro-2-diazomethyl-*s*-triazine. By recrystallization from ligroin a yellowish micro-crystalline powder was obtained, m.p. 186° dec.

Anal. Calcd. for $C_4H_3ClN_6$: C, 28.17; H, 1.75; Cl, 20.79; N, 49.29. Found: C, 28.54; H, 1.80; Cl, 20.33; N, 49.19.

4,6-Diamino-2-diazomethyl-*s*-triazine (XIX).—Several attempts to prepare XIX either from XVIII or from II directly failed because the last chlorine atom was very difficult to replace by ammonia without alteration of the diazo group. To prevent decomposition of the diazo group it is essential to have free ammonium hydroxide present as long as the crude XIX still contains ammonium chloride. The following procedure yielded an approximately pure product:

A mixture of about 70 ml. of liquid ammonia and 4.75 g. of 2,4-dichloro-6-diazomethyl-1,3,5-triazine was kept at 60° for 8 hr. in an autoclave of 200 ml. volume. After the excess ammonia was allowed to evaporate, the reaction mixture was removed from the autoclave with ice-cold concentrated ammonium hydróxide and filtered off by vacuum. The crude 4,6-diamino-2-diazomethyl-1,3,5-triazine (3.1 g., 82%), which still contained a considerable amount of ammonium chloride, was digested several times with aqueous ammonium hydroxide and the resulting paste dried on a porous plate. To remove the last traces of ammonium chloride, XIX was heated for about one minute with a mixture of 50 ml. of ethyl alcohol, 25 ml. of water and 3 ml. of concentrated ammonium hydroxide and then filtered. The filter cake was extracted with ether and the remaining slightly colored powder dried over potassium hydroxide. The 4,6-diamino-2-diazomethyl-1,3,5-triazine is practically insoluble in the usual solvents at temperatures which do not cause decomposition of the diazo group. Heated under usual conditions, XIX decomposed gradually above 230°. On the Fisher–Johns apparatus a few crystals melted before decomposing when the plate was preheated to 240°.

Anal. Calcd. for $C_4H_5N_7$: C, 31.79; H, 3.34; N, 64.87. Found: C, 31.82; H, 4.18; N, 64.10.

4,6-Bis-diethylamino-2-diazomethyl-*s*-triazine (XXI).—An amount of 4.75 g. of 2-diazomethyl-4,6-dichloro-*s*-triazine (II) in 200 ml. of ligroin (b.p. 60–70°) was added at 0° to diethylamine (20 g.) dissolved in 100 ml. of the same solvent and then the reaction mixture refluxed for 2 hr. The precipitated salts were filtered off and the filtrate was washed several times with water, dried over potassium carbonate and the solvent removed by distillation. The desired compound XXI remained as a yellow oil (5.45 g., 83%). It could be purified by vacuum distillation, b.p. 110–115° (0.035 mm.).

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[10] A. Ostrogovich, *Chem. Ztg.*, **36**, 738 (1912); R. Hirt, H. Nidecker and E. Berchtold, *Helv. Chim. Acta*, **33**, 1365 (1950).

Anal. Calcd. for $C_{12}H_{21}N_7$: C, 54.73; H, 8.04. Found: C, 54.38; H, 8.12.

When the reaction was carried out with only two moles of diethylamine in ether at room temperature and worked up after 24 hr., the substitution was limited to one chlorine atom, resulting in **6-chloro-2-diazomethyl-4-diethylamino-*s*-triazine (XX)**. Yellow prisms (4.5 g., 79%) were obtained from ligroin, m.p. 52.5°. *Anal.* Calcd. for $C_8H_{11}ClN_6$: C, 42.39; H, 4.89; Cl, 15.64; N, 37.08. Found: C, 42.23; H, 4.93; Cl, 14.91; N, 37.07.

4,6-Bis-ethyleneimino-2-diazomethyl-*s*-triazine (XXII) was obtained in 52% yield by reaction of II with ethyleneimine (two moles) and triethylamine (two moles) in boiling ether in an analogous manner. Recrystallization from ligroin (b.p. 60–70°) yielded a yellow powder, which decomposed at 108° without melting.

Anal. Calcd. for $C_8H_9N_7$: C, 47.28; H, 4.47. Found: C, 47.32; H, 4.52.

Conversion of the Diazomethyl-*s*-triazines into the Dihalogenomethyl-*s*-triazines.—The finely powdered diazo compound (II resp. XIII) was suspended in carbon tetrachloride containing one mole of the required halogen and kept at room temperature with stirring for 24 hr. If the halogen had not yet reacted completely, the reaction mixture was then refluxed for 2–3 hr., filtered from solid by-products and the solvent removed by distillation. The residue was fractionated twice under vacuum. In the case of the di-iodo derivative XXIV, which decomposes on heating, the crude product was recrystallized from ligroin. Data of the individual compounds are compiled in Table I.

Reaction of the 2-Diazomethyl-*s*-triazines with Acids.—The diazomethyltriazines II and XIII were dissolved in ether and an excess of hydrogen chloride passed in, followed by refluxing for 3 hr. After filtering off the insoluble hydrochlorides and evaporating the ether, the products XXVII and XXVIII were isolated by vacuum distillation or recrystallization from ligroin. The amount of the insoluble hydrochlorides could be considerably increased if the treatment with hydrochloric acid was extended for two days. For example, from 12.6 g. of 2-diazomethyl-4,6-dimethoxy-*s*-triazine (XIII) in 1500 ml. of pure anhydrous ether, we obtained 10.1 g. of the crude **hydrochloride of 2-chloromethyl-4,6-dihydroxy-*s*-triazine (XXIX)** (found: N, 21.12, 21.25; Cl, 36.02, 36.13). From the mother liquor another crop (0.6 g.) of XXIX deposited after standing overnight (for analysis *cf.* Table II).

XXIX was characterized by coupling it in alkaline solution with β-naphthol in 90% yield to the **4,6-dihydroxy-2-[2'-naphthoxymethyl]-*s*-triazine.** After recrystallization from acetic acid, glistening leaflets were obtained, m.p. 300° dec.

Anal. Calcd. for $C_{14}H_{11}N_3O_3$: C, 62.45; H, 4.11; N, 15.61. Found: C, 62.45, 62.36; H, 4.08, 4.16; N, 15.56, 15.62.

The conversion of XIII into the carbinol XXX occurred spontaneously with evolution of heat when 4.75 g. of XIII was suspended in 50 ml. of water and 0.6 g. of concd. sulfuric acid was added. After all had gone into solution, the carbinol was extracted five times with ether, the combined ethereal extracts evaporated and the solid residue recrystallized from ligroin. The diazomethyltriazines in general reacted much more easily with organic acids in the presence of a small amount of water. Thus the conversion of XIII into the acetate XXXI was best effected with 90% acetic acid. The spontaneous reaction was completed by refluxing for 10 minutes. After diluting with much water and neutralizing with sodium bicarbonate, XXXI was extracted with ether. The residue remaining after evaporation of the ether was recrystallized from ligroin. The reaction of XIII and XXI with the aromatic acids was carried out in xylene with an excess of the acid and addition of about 1% of water. After refluxing for 3–4 hr., the reaction mixture was diluted with ether and the excess acid extracted with sodium bicarbonate solution. The solvents were then removed by distillation, the last of the xylene being removed under vacuum. The residue was recrystallized from ligroin, in the case of XXXIII preferably by seeding. Physical and analytical data for the above compounds are compiled in Table II.

2-Chloromethyl-4,6-diamino-*s*-triazine (XXXIV).—A saturated solution of ammonia in ethanol (25 ml.) was added dropwise at 0° to a solution of 3.2 g. of 2-chloromethyl-4,6-dichloro-*s*-triazine (XXVII) in 3 ml. of anhydrous ether. The yellowish precipitate was collected and recrystallized twice from 20 ml. of water with addition of charcoal to give white needles (1.7 g., 66%). The substance XXXIV darkened above 220° but did not melt up to 330°.

Anal. Calcd. for $C_4H_6ClN_5$: C, 30.11; H, 3.79; Cl, 22.21; N, 43.89. Found: C, 30.81; H, 3.83; Cl, 21.84; N, 43.37.

COLUMBUS, OHIO

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, KANSAS STATE COLLEGE]

Oxetanes. VI.[1] Reductive Cleavage and Substituent Effects[2]

BY SCOTT SEARLES, JR., KENNETH A. POLLART AND EUGENE F. LUTZ

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Reductive cleavage of ten oxetanes, having two or fewer alkyl substituents, has been carried out with lithium aluminum hydride and that of 2-phenyloxetane, with lithium borohydride. A single alcohol product was formed in each case, cleavage of unsymmetrical oxetanes occurring between the oxygen atom and the least substituted α-carbon atom. The ease of cleavage was found to be much affected by substitution, particularly *gem*-dialkyl substitution at position 3, which caused marked deactivation. These substituent effects are discussed. The preparations of 2-phenyloxetane and 3-methyloxetane are described for the first time.

Reductive cleavage of the oxetane (trimethylene oxide) ring would be of obvious value in establishing the structure of new oxetanes, as well as in certain synthetic applications. Reductive cleavage of 1,2-epoxides has been very widely and successfully used,[3,4] and its extension to oxetanes was suggested by the fairly high degree of reactivity observed for trimethylene oxide in Grignard reactions and in other reactions.[1]

The smooth cleavage of trimethylene oxide with lithium aluminum hydride, forming *n*-propyl alcohol, was reported in a preliminary fashion several

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[1] Earlier papers considered to be in this series are: (a) S. Searles, THIS JOURNAL, **73**, 124 (1951); (b) 4515 (1951); (c) S. Searles and C. F. Butler, *ibid.*, **76**, 56 (1954); (d) S. Searles, *ibid.*, 2313 (1954); S. Searles and V. P. Gregory, *ibid.*, 2789 (1954).

[2] Portions of the dissertations presented by K. A. P. (1956) and to be presented by E. F. L. in partial fulfillment of the requirement for the degree Doctor of Philosophy in Chemistry at Kansas State College.

[3] Lithium aluminum hydride reductions are reviewed by W. B Brown in Adams' "Organic Reactions," Vol. VI, John Wiley and Sons, Inc., New York, N. Y., 1951, p. 476.

[4] M. S. Newman, G. Underwood and M. Renoll, THIS JOURNAL, **71**, 3362 (1949).