*Decarboxylation.* The crude carboxylic acid was heated above its melting point in a sublimation apparatus at 35 mm. A sublimate of fine yellow needles was obtained. After recrystallization from aqueous ethanol this material was identified by m.p. (87–88°) as 8-nitroisoquinoline. This solid gave a picrate, m.p. 183–184°; reported for 8-nitroisoquinoline, m.p. 87–87.5[2]; reported for 5-nitroisoquinoline, m.p. 110.5–111.5°[2]; picrate, m.p. 220°.[7] The ultraviolet spectrum of this solid had maximum at 234 mμ, 292 mμ, and 330 mμ; reported[2] for 8-nitroisoquinoline 235 mμ, 292 mμ, and 328 mμ.

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(7) P. Fortner, *Monatsh.*, **14**, 146 (1893).

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## Reactions of *s*-Triazine Aldehydes[1]

EHRENFRIED KOBER[2]

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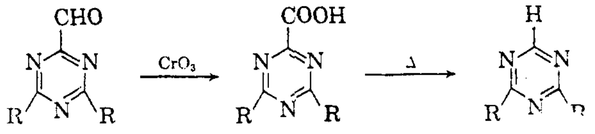
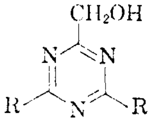
After synthesis and properties of 4,6-dimethoxy-*s*-triazine-2-aldehyde (I) and 4,6-bis(methylthio)-*s*-triazine-2-aldehyde (II) had been reported,[3] the reactivity of these first representatives of a novel class of aldehydes was investigated.

It is known that *N*-heterocyclic 2-aldehydes, containing the partial structure —N=C—CHO, are remarkably resistant to oxidation.[4] Therefore, it is not surprising that the formation of the triazine carboxylic acids III and IV from aldehydes I and II by autoxidation could not be realized.[3] Conversion to the desired carboxylic acids could also not be achieved by oxidizing agents such as hydrogen peroxide, nitric acid, potassium permanganate, or silver oxide which either did not affect the aldehyde group at all or attacked simultaneously the methoxy or methylthio substituents. The carboxylic acids III and IV were formed, however, when the oxidation was carried out with chromic acid. 4,6-Dimethoxy-*s*-triazine-2-carboxylic acid (III) could not be separated from its reaction mixture by means of solvents. Isolation by vacuum sublimation could not be accomplished, since compound III decarboxylated to give 2,4-dimethoxy-*s*-triazine (V). In contrast to III, the corresponding 4,6-bis(methylthio)-*s*-triazine-2-carboxylic acid (IV) is soluble in ether and was, therefore, easily isolated. When subjected to thermal decarboxylation, IV yielded 2,4-bis(methylthio)-*s*-triazine (VI).

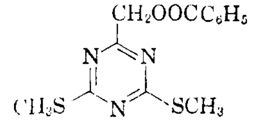


I. R = $OCH_3$
II. R = $SCH_3$
III. R = $OCH_3$
IV. R = $SCH_3$
V. R = $OCH_3$
VI. R = $SCH_3$

The hydrogenation of compounds I and II with sodium borohydride gave, as expected, 2-hydroxymethyl-4,6-dimethoxy-*s*-triazine (VII) and 2-hydroxymethyl-4,6-bis(methylthio)-*s*-triazine (VIII). Compound VII proved to be identical with an authentic sample,[5] whereas VIII was identified by its reaction with benzoyl chloride which afforded 2-benzoxymethyl-4,6-bis(methylthio)-*s*-triazine (IX).



VII. R = $OCH_3$
VIII. R = $SCH_3$



IX

The acyloin condensation of compounds I and II resulted in yellow precipitates which were insoluble or only slightly soluble in the usual organic solvents, but could be recrystallized from pyridine. Analyses of the yellow, crystalline products thus obtained, corresponded perfectly with those of the expected acyloins; however, in view of their low solubility and their color it is assumed that these products are endiols, represented by structural formulas X and XI. Corresponding structures have also been postulated for the compounds obtained from the acyloin condensation of quinoline-2-aldehydes[6,7] and of pyridine-2-aldehyde.[8,9]

As additional products of the condensation, the corresponding glycols (XII and XIII) were isolated. Their formation can be explained by the assumption that a Cannizzaro reaction, catalyzed by potassium cyanide, took place as a side reaction In the case of aldehyde II, the occurrence of a simultaneous Cannizzaro reaction was confirmed by the isolation of a third reaction product, namely ethyl 4,6-bis(methylthio)-*s*-triazine-2-carboxylate (XIV). Apparently, the aldehyde II reacts in ethanolic solution in form of its ethyl hemi-acetal[3] to give the ethyl ester (XIV) instead of the free acid.

In this connection it should be noted that the Cannizzaro reaction of aldehydes I and II, carried out in the presence of potassium hydroxide, did not result in the expected compounds III and VII, or IV and VIII, respectively. As experienced in some

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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 Olin Mathieson Chemical Corp., New York, N. Y.

[2] Olin Mathieson Chemical Corp., New Haven, Conn.

[3] E. Kober and Ch. Grundmann, *J. Am. Chem. Soc.*, **80**, 5547 (1958).

[4] Houben-Weyl, *Methoden der Organischen Chemie*, Vol. VII, I, p. 498, Georg Thieme Verlag, Stuttgart, 1954.

[5] Ch. Grundmann and E. Kober, *J. Am. Chem. Soc.*, **79**, 944 (1957).

[6] C. A. Buehler and J. O. Harris, *J. Am. Chem. Soc.*, **72**, 5015 (1950).

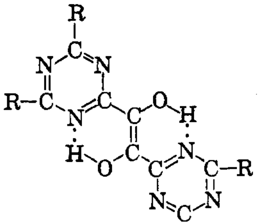
[7] C. A. Buehler and S. P. Edwards, *J. Am. Chem. Soc.*, **74**, 977 (1952).

[8] F. Cramer and W. Krum, *Ber.*, **86**, 1586 (1953).

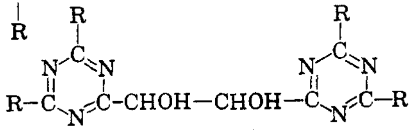
[9] W. Mathes, W. Sauermilch, and Th. Klein, *Ber.*, **84**, 452 (1951).

oxidation experiments, the strong alkali cleaved the methoxy or methylthio groups of I and II, and probably also the *s*-triazine nucleus.

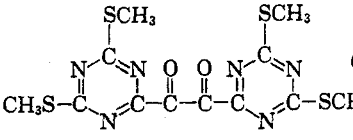
Oxidation of the enediol XI by means of oxygen in methanolic solution gave the expected dione (XV). In an attempt to prepare the acid IV from XI by catalyzed oxidation with ferric chloride, methyl 4,6-bis(methylthio)-*s*-triazine-2-carboxylate (XVI) was isolated in addition to the dione XV. Again, the formation of the methyl ester (XVI) is tentatively explained by the assumption that a hemi-acetal is formed and oxidized in the course of the reaction. In addition, it could also be possible that the free acid was formed as an intermediate and subsequently esterified by means of the ferric chloride catalyst.



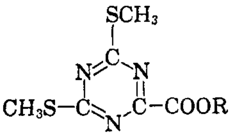
X. R = $OCH_3$
XI. R = $SCH_3$



XII. R = $OCH_3$
XIII. R = $SCH_3$

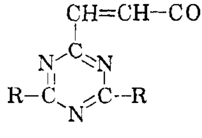


XV

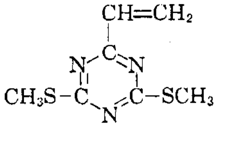


XIV. R = $C_2H_5$
XVI. R = $CH_3$

The condensation of aldehydes I and II with malonic acid in pyridine resulted in the expected acrylic acid derivatives XVII and XVIII. In the case of II, the decarboxylation product of XVIII, 2,4-bis(methylthio)-6-vinyl-*s*-triazine (XIX), was formed as a by-product, but could only be isolated in form of a dimer.



XVII. R = $OCH_3$
XVIII. R = $SCH_3$



XIX

## EXPERIMENTAL[10]

*2,4-Dimethoxy-s-triazine* (V). A 2% solution of chromic acid in acetic acid (34.3 ml.) was added dropwise, with stirring, to 1.69 g. (0.01 mole) of 4,6-dimethoxy-*s*-triazine-2-aldehyde (I) in 40 ml. of acetic acid. The mixture was allowed to stand at room temperature. The acetic acid was then removed *in vacuo* to give a dark, solid residue which could not be recrystallized from the usual solvents. Therefore, the residue was sublimed at 0.25 mm. by heating with an open flame. The slightly yellowish sublimate (0.23 mg.) was recrystallized from a small amount of ethanol to yield colorless needles of 2,4-dimethoxy-*s*-triazine (V), m.p. 168–169°.

*Anal.* Calcd. for $C_5H_7N_3O_2$: C, 42.55; H, 5.00; N, 29.77. Found: C, 42.55; H, 5.04; N, 29.73.

*4,6-Bis(methylthio)-s-triazine-2-carboxylic acid* (IV). A 2% solution of chromium trioxide in acetic acid (35 ml.) was added dropwise, with stirring, to the solution of 2.01 g. (0.01 mole) of 4,6-bis(methylthio)-*s*-triazine-2-aldehyde (II) in 40 ml. of acetic acid. The mixture was allowed to stand at room temperature for 3 days and then freed by filtration from a very small amount of a solid by-product. The acetic acid was removed *in vacuo* from the filtrate and the dark, solid residue extracted with ether in a Soxhlet apparatus for 3 hr. After evaporation of the ether, the resulting residue (0.45 g.) was recrystallized from a mixture of 150 ml. of petroleum ether (b.p. 90–97°) and 2 ml. of ethanol to afford IV in form of yellowish leaflets, m.p. 172–174° dec.

*Anal.* Calcd. for $C_6H_7N_3O_2S_2$: C, 33.17; H, 3.26; N, 19.34; S, 29.51. Found: C, 33.27; H, 3.41; N, 19.34; S, 29.39.

*2,4-Bis(methylthio)-s-triazine* (VI). An amount of 6.03 g. (0.3 mole) of II in 60 ml. of acetic acid was treated with a solution of 2 g. of chromium trioxide in 55 ml. of acetic acid as described for the preparation of IV. After removal of the solvent, the residue (9.5 g.) was sublimed at 0.5 mm. by heating with an open flame. The sublimate (2.3 g.) was recrystallized from a small amount of methanol to give VI in form of white leaflets, m.p. 59–60°, which have a strong mouse-like odor.

*Anal.* Calcd. for $C_5H_7N_3S_2$: C, 34.66; H, 4.07; N, 24.26; S, 37.01. Found: C, 34.73; H, 4.07; N, 24.33; S, 36.99.

*2-Hydroxymethyl-4,6-dimethoxy-s-triazine* (VII). A 1.7-g. sample of the aldehyde I was dissolved in 50 ml. of methanol and 0.4 g. of sodium borohydride was added, with stirring, at 0°. The reaction mixture was allowed to warm up and kept at room temperature for 15 hr. with continuous stirring. The methanol was removed *in vacuo* and the dry residue was extracted with ether. After the ether had been evaporated, the resulting white residue was extracted with hot petroleum ether (b.p. 90–97°), from which colorless crystals (m.p. 108–109°, 1.2 g.) precipitated upon cooling. A mixed melting point of these crystals with 2-hydroxymethyl-4,6-dimethoxy-*s*-triazine (VII)[5] showed no depression.

*2-Hydroxymethyl-4,6-bis(methylthio)-s-triazine* (VIII). A 4.02-g. sample of the aldehyde II was dissolved in 100 ml. of methanol and 0.8 g. of sodium borohydride was added, with stirring, at 0°. The dark solution was allowed to warm up and stirred at room temperature for 15 hr. The methanol was removed from the reaction mixture and the residue dissolved in water. The aqueous solution was extracted three times with ether. After the ether was removed from the combined extracts, the solid residue (4.1 g.) was extracted three times with hot petroleum ether (b.p. 90–97°) from which 1.05 g. of yellow needles precipitated upon cooling at −20°. Further recrystallization from the petroleum ether or from water yielded slightly yellowish needles, which proved to be 2-hydroxymethyl-4,6-bis(methylthio)-*s*-triazine (VIII), m.p. 90°.

*Anal.* Calcd. for $C_6H_9N_3S_2O$: C, 35.45; H, 4.46; N, 20.68; S, 31.54. Found: C, 35.59; H, 4.41; N, 20.84; S, 31.41.

Compound VIII was further identified by its reaction with benzoyl chloride in pyridine which gave *2-benzoxymethyl-4,6-bis(methylthio)-s-triazine* (IX) in form of slightly yellowish, fine needles, m.p. 91.5–92°.

*Anal.* Calcd. for $C_{13}H_{13}N_3S_2O_2$: C, 50.80; H, 4.26; N, 13.67; S, 20.86. Found: C, 51.05; H, 4.26; N, 13.68; S, 20.53.

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(10) Melting points are uncorrected (Fisher-Johns); analyses are by Spang, Microanalytical Laboratory, Ann Arbor, Mich.

*1,2-Bis[2,4-dimethoxy-s-triazinyl-(6)]ethenediol(1,2)* (X) *and 1,2-bis[2,4-dimethoxy-s-triazinyl(6)]ethanediol (1,2)* (XII). A 3.5-g. sample of the aldehyde I was dissolved in 50 ml. of absolute ethanol. A yellow compound precipitated immediately when 0.4 g. of potassium cyanide in 50 ml. of absolute ethanol was added to the solution at room temperature. After 4 hr. the yellow precipitate (0.4 g.) was filtered by suction. It was insoluble or only slightly soluble in solvents such as water, ethanol, or petroleum ether (b.p. 90–97°), but could be recrystallized from pyridine to yield compound X as fine, yellow needles which melted at 230° dec.

*Anal.* Calcd. for $C_{12}H_{14}N_6O_6$: C, 42.60; H, 4.17; N, 24.84. Found: C, 42.58; H, 4.18; N, 24.71.

After the yellow enediol (X) had been filtered, the alcoholic mother liquor was allowed to stand at room temperature for a few days, whereupon the glycol XII precipitated in form of white crystalline spheroids (0.35 g.). Recrystallization from ethanol gave white needles melting at 185–187°.

*Anal.* Calcd. for $C_{12}H_{16}N_6O_6$: C, 42.35; H, 4.74; N, 24.70. Found: C, 42.48, 42.52; H, 4.59, 4.76; N, 24.71, 24.64; mol. wt., (Rast): Calcd.: 340. Found: 340, 326.

A further crop (0.2 g.) of the glycol XII was obtained when the alcoholic mother liquor was removed *in vacuo* and the residue was recrystallized from ethanol.

*1,2-Bis[2,4-bis(methylthio)-s-triazinyl-(6)]ethenediol-(1,2)* (XI), *1,2-bis[2,4-bis(methylthio)-s-triazinyl-(6)]ethanediol-(1,2)* (XIII), *and ethyl 4,6-bis(methylthio)-s-triazine-2-carboxylate* (XIV). A 2.6-g. sample of potassium cyanide in 100 ml. of absolute ethanol was added to the solution of 20.1 g. of the aldehyde II in 200 ml. of absolute ethanol, whereupon a yellow solid precipitated which was filtered by suction after the reaction mixture had been allowed to stand at room temperature for 3 days. The yellow powder (9.8 g.) was only slightly soluble or insoluble in water, ethanol or ether, but could be recrystallized from pyridine to yield the enediol XI as fine, yellow needles which melted at 272–274° dec.

*Anal.* Calcd. for $C_{12}H_{14}N_6S_4O_2$: C, 35.81; H, 3.50; N, 20.88; S, 31.86. Found: C, 35.91; H, 3.33; N, 20.91; S, 32.27.

After the ethanol was removed from the filtrate, a solid was obtained which was extracted with ether. Removal of the ether from the extract yielded yellowish crystals (2.0 g.) melting at 88–89° after recrystallization from petroleum ether (b.p. 90–97°). These crystals were very soluble in acetone, methanol, and ethanol. For final purification they were recrystallized from 10 ml. of ethanol to give yellowish colored crystals, m.p. 91–91.5°, which proved to be ethyl 4,6-bis(methylthio)-*s*-triazine-2-carboxylate (XIV).

*Anal.* Calcd. for $C_8H_{11}N_3S_2O_2$: C, 39.01; H, 4.49; N, 17.06; S, 26.03. Found: C, 39.21; H, 4.56; N, 17.24; S, 26.17; mol. wt., (Rast): Calcd. 245.2. Found: 229.

The glycol XIII was isolated from the solid which was left after the ethyl ester XIV had been extracted with ether. This residue was recrystallized from a small amount of acetic acid to yield crystals (0.2 g.) which had a melting point of 192–193° and the composition of the glycol XIII.

*Anal.* Calcd. for $C_{12}H_{16}N_6S_4O_2$: C, 35.60; H, 3.98; N, 20.76; S, 31.70. Found: C, 35.59; H, 4.34; N, 20.97; S, 31.91.

*1,2-Bis[2,4-bis(methylthio)-s-triazinyl-(6)]ethanedione-(1,2)* (XV) *and methyl 4,6-bis[(methylthio)-s-triazine-2-carboxylate* (XVI). The enediol XI (4.0 g.) was shaken in methanolic emulsion with pure oxygen for several hours, although the oxygen consumption ceased after about 1 hr. The methanol-insoluble, yellow dione XV (3.75 g.) was filtered from the reaction mixture and recrystallized from pyridine to give pure XV, m.p. 256–258° dec.

*Anal.* Calcd. for $C_{12}H_{12}N_6S_4O_2$: C, 35.99; H, 3.02; N, 20.99; S, 32.02. Found: C, 36.03, 35.91; H, 3.57, 3.64; N, 20.94, 21.02; S, 32.07, 32.19.

The same experiment was repeated with a catalytic amount of ferric chloride present. A considerable amount of the dione XV (61%) was isolated from the reaction mixture as described above. The methyl triazine carboxylate (XVI) was isolated by evaporation of the methanolic mother liquor and extraction of the dry residue with ether. Removal of the ether from the extract gave crude XVI (1.35 g.) which was recrystallized from a small amount of ethanol to yield methyl 4,6-bis(methylthio)-*s*-triazine-2-carboxylate (XVI) as yellow spheroids, m.p. 126–127°.

*Anal.* Calcd. for $C_7H_9N_3S_2O_2$: C, 36.35; H, 3.92; N, 18.17. Found: C, 36.45; H, 3.99; N, 17.90; mol. wt. (Rast): Calcd. 231.2. Found: 232, 225.

*4,6-Dimethoxy-s-triazine-2-acrylic acid* (XVII). A 3.4-g. sample of the aldehyde I was dissolved in 20 ml. of anhydrous pyridine which contained a few drops of piperidine. Then 2.6 g. of powdered malonic acid was added, the reaction mixture was allowed to stand at room temperature for 1 day, and was finally heated at 100° for 8 hr., whereupon carbon dioxide was evolved. After evaporation of the solvent *in vacuo*, the dark, sticky residue was digested with acetone. After filtration from insoluble by-products, the acetone was removed *in vacuo*. The residue thus obtained was digested with 20 ml. of 2*N* hydrochloric acid, whereupon 1.7 g. of a solid product precipitated. This compound was dissolved in ether and insoluble by-products were removed by filtration. After the ether had been removed *in vocuo* from the filtrate, the solid residue was recrystallized from a small amount of water to yield glittering leaflets of 4,6-dimethoxy-s-triazine-2-acrylic acid (XVII, 1.1 g.), m.p. 159°.

*Anal.* Calcd. for $C_8H_9N_3O_4$: C, 45.50; H, 4.29; N, 19.90. Found: C, 45.59; H, 4.41; N, 19.99.

*4,6-Bis(methylthio)-s-triazine-2-acrylic acid* (XVIII) *and dimeric 2,4-bis(methylthio)-6-vinyl-s-triazine* (XIX). A 2.6-g. sample of powdered malonic acid was added to the solution of 4 g. of the aldehyde II in 20 ml. of pyridine containing 1 drop of piperidine. The mixture was allowed to stand at room temperature for 36 hr. A slight evolution of carbon dioxide could be observed. To complete the reaction, the solution was kept at 100° for 6 hr. After cooling, the pyridine was removed *in vacuo* and the dark, sticky residue digested with 50 ml. of acetone, whereupon 0.7 g. of a solid compound precipitated which was filtered by suction.

This compound was insoluble in boiling water, warm 2*N* hydrochloric acid, concd. sodium bicarbonate, sodium carbonate, or sodium hydroxide. It was recrystallized from ethanol and, finally, from acetic acid to give light brown crystals, m.p. 159–160°. According to its composition this compound is 2,4-bis(methylthio)-6-vinyl-*s*-triazine (XIX). The molecular weight determination, however, indicated that it is a dimer.

*Anal.* Calcd. for $(C_7H_9N_3S_2)_2$: C, 42.19; H, 4.55; N, 21.09; S, 32.17. Found: C, 42.21; H, 4.48; N, 21.08; S, 32.08; mol. wt. (Rast): Calcd. 398. Found: 392, 390.

4,6-Bis(methylthio)-*s*-triazine-2-acrylic acid (XVIII) was isolated by removing the acetone from the filtrate mentioned above. The dark residue thus obtained was digested with acetic acid to result in the precipitation of crude XIX (0.4 g.) which was filtered by suction. After several days, needles (0.65 g.) had precipitated from the acetic acid filtrate. These crystals were soluble in sodium bicarbonate and could be recrystallized from a very small amount of acetic acid to give the triazine acrylic acid XVIII as fine needles, m.p. 195–196°.

*Anal.* Calcd. for $C_8H_9N_3S_2O_2$: C, 39.50; H, 3.73; S, 26.35. Found: C, 39.85; H, 3.71; S, 25.82.

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