for 24 hr., the reaction mixture was placed in a refrigerator for one week. The crystalline material present was collected by filtration and recrystallized twice from methanol-methyl acetate; yield 4.2 g. (68%), m.p. 131–132°.

Anal. Calcd. for $C_{10}H_8N_2O_8$: C, 42.26; H, 2.84; N, 9.86; mol. wt., 284. Found: C, 42.00; H, 2.83; N, 9.66; mol. wt. (Rast), 272, 286.

B. From reaction of sodium 3,5-dinitrobenzoate with methyl chloroacetate. Reaction of methyl chloroacetate and sodium 3,5-dinitrobenzoate in aqueous methanol containing sodium iodide according to the general method of Einhorn and Seuffert[8] gave an 82% yield of methyl *O*-(3,5-dinitrobenzoyl)-glycollate, m.p. 131–132°, no depression upon admixture with the compound prepared as in *A*. The infrared spectra of the products prepared by the two methods were identical, and possessed absorption bands at 1745 (ester carbonyl), 1725 (ester carbonyl), 1535, 1350, 1225, 1160, and 719 cm.$^{-1}$

C. From reaction of 3,5-dinitrobenzoic acid with methyl diazoacetate. 3,5-Dinitrobenzoic acid (5 g., 0.024 mole) was dissolved in 30 ml. of methyl acetate and added to 10 ml. of methyl diazoacetate (0.11 mole) at 5°. No immediate evolution of gas was noticed. The reaction mixture was allowed to stand for 24 hr. at room temperature, then for two weeks at 0°. At the end of this time a crystalline product was collected and recrystallized from methanol-methyl acetate; yield, 1.2 g. (18%), m.p. and mixed m.p., 131–132°.

α-Naphthoic anhydride. To 5.6 g. (0.056 mole) of methyl diazoacetate at 5° was added a 5-g. quantity (0.026 mole) of α-naphthoyl chloride. Gas evolution commenced immediately. After standing at 0–5° for one week, the crystalline product then present was collected by filtration and recrystallized twice from methanol-methyl acetate; yield 2.8 g. (66%), m.p. 147–148° [lit.[20] m.p., 148°]. The infrared absorption spectrum showed a prominent band at 1762 cm.$^{-1}$, attributed to the anhydride carbonyl group.[9]

Anal. Calcd. for $C_{22}H_{14}O_3$: C, 80.96; H, 4.32. Found: C, 80.67; H, 4.33.

β-Naphthoic anhydride. To 5.6 g. (0.056 mole) of methyl diazoacetate at 5° was added a 5-g. quantity (0.026 mole) of β-naphthoyl chloride, dissolved in *ca.* 30 ml. of methyl acetate. After standing at 0–5° for three weeks, the crystalline product then present was collected by filtration and recrystallized from methanol-methyl acetate; yield, 2.0 g. (48%), m.p. 137–138° [lit.[21] m.p. 134°]. The infrared spectrum displayed a prominent absorption maximum at 1775 cm.$^{-1}$, due to the carboxylic anhydride carbonyl group.[9]

Anal. Calcd. for $C_{22}H_{14}O_3$: C, 80.96; H, 4.32. Found: C, 80.67; H, 4.31.

o-Iodobenzoic anhydride. To 4 ml. (0.045 mole) of methyl diazoacetate at 5° was added a 5-g. quantity (0.019 mole) of liquid *o*-iodobenzoyl chloride (warmed if necessary). Gas evolution commenced immediately. After standing at room temperature one day and at 0° for one week, the crystalline product then present was collected by filtration and recrystallized from methanol-methyl acetate; yield, 3.0 g., (66%), m.p. 76–77°. The infrared absorption spectrum showed a strong maximum at 1790 cm.$^{-1}$

Anal. Calcd. for $C_{14}H_8O_3I_2$: C, 35.20; H, 1.69. Found: C, 35.50; H, 1.75.

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[CONTRIBUTION NO. 1016 FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF PITTSBURGH]

Chemistry of Pyrazine and its Derivatives. I. The Hypohalite Oxidation of Acetonyl- and Phenacylpyrazine[1]

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Acetonylpyrazine has been oxidized with potassium hypochlorite solution to give a mixture of what is believed to be dichloromethylpyrazine (III) (78%) and acetic acid (36%). Similarly, phenacylpyrazine gives a mixture of III (37%) and benzoic acid (56%). The reaction of III with methanolic sodium methoxide gave a 79% yield of the dimethyl acetal of pyrazinealdehyde.

As part of an extensive study of the chemistry of pyrazine and its derivatives, we have prepared a series of ketones in high yields by acylating the side chain of methylpyrazine with a variety of esters using sodium amide in liquid ammonia as the condensing agent.[3] Acetonylpyrazine and phenacylpyrazine are two of the ketones which were prepared by this method.

It was of interest to treat acetonylpyrazine, I, with potassium hypochlorite as a possible route to the previously unreported pyrazineacetic acid (II). However, none of the desired acid was obtained. Instead, what is believed to be dichloromethylpyrazine (III) (78%) and acetic acid (36%) were isolated. When phenacylpyrazine was treated similarly, a mixture of III (37%) and benzoic acid

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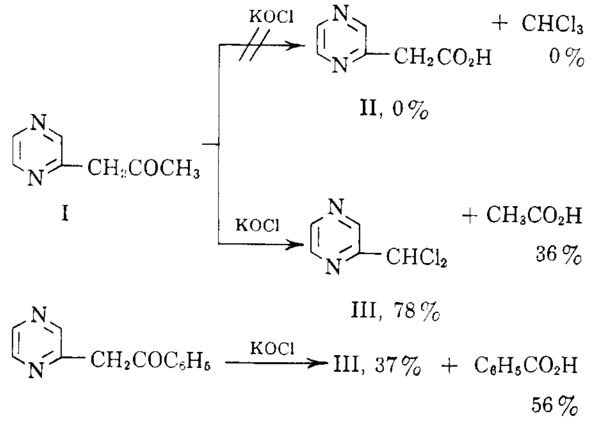
(2) This paper is based on part of the thesis to be presented by John D. Behun to the Graduate Faculty of the University of Pittsburgh in partial fulfillment of the requirements of the Ph.D. degree.

(3) J. D. Behun and R. Levine, page 9N of the Abstracts of the 130th meeting of the American Chemical Society, Atlantic City, N. J., September 16–21, 1956; the details of these acylations will be published shortly.

(56%) was obtained. The reactions involved are shown in the following scheme.



Although preliminary attempts to hydrolyze III to pyrazinealdehyde have failed, the hydrolysis study is being continued. However, it was found that III could be converted to the dimethylacetal of pyrazinealdehyde in 79% yield by reaction with methanolic sodium methoxide.

The study of the hypohalite oxidation of a variety of active hydrogen compounds which was initiated several years ago is being continued.[4,5]

EXPERIMENTAL[6]

Oxidation of acetonylpyrazine by potassium hypochlorite. An aqueous solution of potassium hypochlorite was prepared according to the method described in the literature.[7] Thus, a solution containing 30 g. of potassium carbonate and 5 g. of potassium hydroxide, dissolved in 40 ml. of water, was added to 50 g. of Pittchlor (commercial bleach) in warm water.

To this rapidly stirred solution, 19.0 g. (0.14 mole) of acetonylpyrazine was added over a 15-min. period. The reaction temperature rose to 50° during the addition of the acetonylpyrazine and a white precipitate formed. Stirring was continued for an additional hour and then the unreacted hypochlorite was destroyed by adding sodium bisulfite solution. The mixture was made weakly acidic with dilute hydrochloric acid and was filtered to remove the inorganic solids which were present. The filter cake was triturated with ether and filtered and the ether washings were combined with the ether extracts of the filtrate. The combined ether phases were dried over anhydrous sodium sulfate and the solvent was then removed by distillation at atmospheric pressure. Distillation of the residue gave 3.0 g. (35.8%) of acetic acid, b.p. 110–118° at atmospheric pressure. A sample of this acid was converted to acetanilide, m.p. 113–114° alone and when mixed with an authentic sample. The residue was distilled *in vacuo* to give 17.8 g. (78%) of dichloromethylpyrazine, b.p. 87–90° at 10 mm.

Anal. Calcd. for $C_5H_4N_2Cl_2$: C, 36.84; H, 2.47; N, 17.19; Cl, 43.50. Found: C, 36.78; H, 2.39; N, 17.11; Cl, 42.77.

Oxidation of phenacylpyrazine with potassium hypochlorite. Using the procedure described above, phenacylpyrazine (10.0 g., 0.05 mole) was oxidized by potassium hypochlorite to give dichloromethylpyrazine (3.0 g., 37%) and benzoic acid (3.4 g., 56.2%), m.p. 121–122° alone and when mixed with an authentic sample.

Preparation of the dimethyl acetal of pyrazinealdehyde. Commercial sodium methoxide (3.0 g., 0.05 mole) was added to dichloromethylpyrazine (7.1 g., 0.044 mole), which was dissolved in 50 ml. of anhydrous methanol. The reaction was very exothermic and it was necessary to cool the mixture in an ice bath. After the reaction mixture had come to room temperature, it was refluxed for two hours, cooled to room temperature and then poured onto ice. The mixture was extracted with several portions of chloroform. Removal of the solvent at atmospheric pressure gave a liquid residue which is a lachrymator and a skin irritant. This residue was dissolved in 40 ml. of anhydrous methanol. Then, additional sodium methoxide (3.0 g., 0.05 mole) was added and the mixture was refluxed for three hours. Finally, the mixture was processed as described above and the residue was distilled *in vacuo* to give 5.1 g. (79.2%) of the dimethyl acetal of pyrazinealdehyde, b.p. 90–94° at 10 mm.

Anal. Calcd. for $C_7H_{10}N_2O_2$: C, 54.53; H, 6.54. Found: C, 54.65; H, 6.49.

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[5] R. Levine and J. R. Stephens, *J. Am. Chem. Soc.*, **72**, 1642 (1950).

[6] The methylpyrazine, which was used in this study, was generously supplied by Wyandotte Chemicals Corp.

[7] M. S. Newman and H. L. Holmes, *Org. Syntheses*, **Coll. Vol. II**, 428 (1943).