mately 0.75% of ethanol. Infrared spectra were determined on a Perkin-Elmer spectrophotometer, Model 237. Chromatograms were made with the flowing method using silica gel; "Silica Gel Davison," from the Davison Co., Baltimore 3, Md. (grade 950; 60–200 mesh) was used without pretreatment. When deactivation by contact with moist air occurred, reactivation was obtained by heating to 170–200° (manufacturer's instructions). The sequence of eluents was hexane, benzene or dry chloroform, ether, ethyl acetate, acetone, and methanol individually or in binary mixtures. The proportion of weight of substance to be absorbed to weight of adsorbent was 1 to 50–100. The proportion of weight of substance in g. to volume of fraction of eluant in ml. was 1 to 100. The ratio of diameter to length of the column was 1 to 20. Evaporations were carried out *in vacuo*, with an outside bath temperature kept below 45°. Amounts of volatile solvent smaller than 20 ml. were evaporated under a stream of dry nitrogen. The microanalyses were done by Dr. M. Manser, Zürich, Switzerland, and Dr. S. M. Nagy, Cambridge, Mass.

Benzyl 2-Acetamido-4,6-benzylidene-2-deoxy-3-*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-α-D-glucopyranoside (III).—A solution of 0.80 g. of benzyl 2-acetamido-4,6,*O*-benzylidene-2-deoxy-α-D-glucopyranoside[14] (II), 0.82 g. of 2,3,4,6-tetra-*O*-acetyl-α-D-galactopyranosyl bromide (I),[13] and 0.56 g. of mercuric cyanide in a mixture of 50 ml. of nitromethane and 30 ml. of benzene was stirred at 40° for 24 hr. with exclusion of moisture. An additional quantity of II (0.40 g.) and mercuric cyanide (0.28 g.) was added and stirring continued for an additional 24 hr. at 40°. The solution was allowed to cool to room temperature, diluted with excess benzene, and washed several times with cold sodium bicarbonate solution and water, dried, and concentrated *in vacuo*. The residue (2.0 g.), dissolved in a mixture of benzene and ether (1:1), was chromatographed on silicic acid. A crystalline fraction was obtained by elution with a mixture of ether and ethyl acetate (9:1). On recrystallization from a mixture of acetone and ether, it gave 0.80 g. of needles (53%), m.p. 175–177°, $[\alpha]^{20}D$ +40° (in chloroform, *c* 1.43).

Anal. Calcd. for $C_{36}H_{41}NO_{15}$: C, 59.42; H, 5.68; N, 1.92. Found: C, 58.95; H, 6.03; N, 1.97.

Benzyl 2-Acetamido-4,6-di-*O*-acetyl-2-deoxy-3-*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-α-D-glucopyranoside (IV).—A solution of 0.80 g. of III in 5 ml. of 60% acetic acid was heated on a steam bath for 15 min. The clear solution obtained was evaporated and the residue, after being dried by repeated azeotropic distillation with toluene, was acetylated with 2 ml. of acetic anhydride and 2 ml. of pyridine at room temperature overnight. Evaporation of this solution and recrystallization of the residue from a mixture of acetone and ether afforded 0.65 g. of needles (82%), m.p. 173–175°. A further recrystallization from the same solvent mixture raised the m.p. to 175–176°, $[\alpha]^{25}D$ +45° (in chloroform, *c* 1.22).

Anal. Calcd. for $C_{33}H_{43}NO_{17}$: C, 54.61; H, 5.97. Found: C, 54.57; H, 6.14.

Benzyl 2-Acetamido-2-deoxy-3-*O*-(β-D-galactopyranosyl)-α-D-glucopyranoside (V).—Saponification of 0.30 g. of IV in 1 ml. of 2 *N* methanolic sodium methoxide solution gave, on cooling, 0.165 g. of needles (84%), m.p. 243–245°. The melting point remained unchanged on recrystallization from methanol, $[\alpha]^{22}D$ +101°(in 95% ethanol, *c* 1.03).

Anal. Calcd. for $C_{21}H_{31}NO_{11}$: C, 53.26; H, 6.59; N, 2.95. Found: C, 53.11; H, 6.76; N, 3.11.

2-Acetamido-2-deoxy-3-*O*-(β-D-galactopyranosyl)-α-D-glucose (VI).—A solution of 160 mg. of V in 5 ml. of 90% ethanol was hydrogenated catalytically with 10% palladium on charcoal, overnight, at room temperature, and atmospheric pressure. The residue, obtained after evaporation, was recrystallized from methanol. After filtration, it was dried for 48 hr. *in vacuo* over phosphorus pentoxide at 80°, giving 100 mg. (77%) of needles, melting at 193–194° dec., after sintering at 184°[22]; the product mutarotated from $[\alpha]^{23}D$ + 32° (0 min.) to +14.5° (after 24 hr.) (in water, *c*, 1.58).[23] The product migrated in descending chromatography, on paper Whatman no. 1, in the mixture of solvents *n*-butyl alcohol, ethanol, and water 10:1:2[24] with an $R_{glucose}$ 0.49.[22]

Anal. Calcd. for $C_{14}H_{25}NO_{15}$: C, 43.85; H, 6.57; N, 3.65. Found: C, 43.75; H, 6.52; N, 3.62.

Acknowledgment.—The authors wish to thank Professor R. Kuhn for kindly supplying a sample of natural 2-acetamido-2-deoxy-3-*O*-(β-D-galactopyranosyl)-α-D-glucose and Charles Pfizer and Company for a gift of *N*-acetylglucosamine.

(22) The natural product supplied by Prof. R. Kuhn was found to melt, under our conditions, at 193–194° after sintering at 186°, and to have an $R_{glucose}$ 0.49 on paper chromatography in the system described.

(23) Kuhn, Gauhe, and Baer[4] reported a mutarotation from 32.0° (0 min.) to +14.0° (at equilibrium) (in water, *c* 2).

(24) R. G. Spiro, *J. Biol. Chem.*, **237**, 646 (1962).

A Reimer–Tiemann Reaction with 6-Trichloromethylpurine[1]

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Phenol undergoes C-acylation at the *para* position with 6-trichloromethylpurine (I) under mild, basic conditions to yield purin-6-yl 4-hydroxyphenyl ketone (III). With *p*-cresol, acylation proceeds at the *ortho* position to yield purin-6-yl 2-hydroxy-5-methylphenyl ketone (VII). An uncharged, reactive intermediate is postulated to account for these and other acylation reactions of I.

In the course of an investigation of the chemical reactivity of 6-trichloromethylpurine (I),[3] it was found that reaction of I with sodium phenoxide in methanol did not lead to the expected 6-(triphenoxymethyl)-purine. Instead, an unstable product, II, was obtained, which, upon mild treatment with aqueous acid, gave rise to a *yellow* ketone, $C_{12}H_8O_2N_4$, III. The isolation of II proved to be difficult; III could be obtained in 79% yield, directly from the reaction mixture of I and sodium phenoxide, by treatment with dilute, aqueous hydrochloric acid.

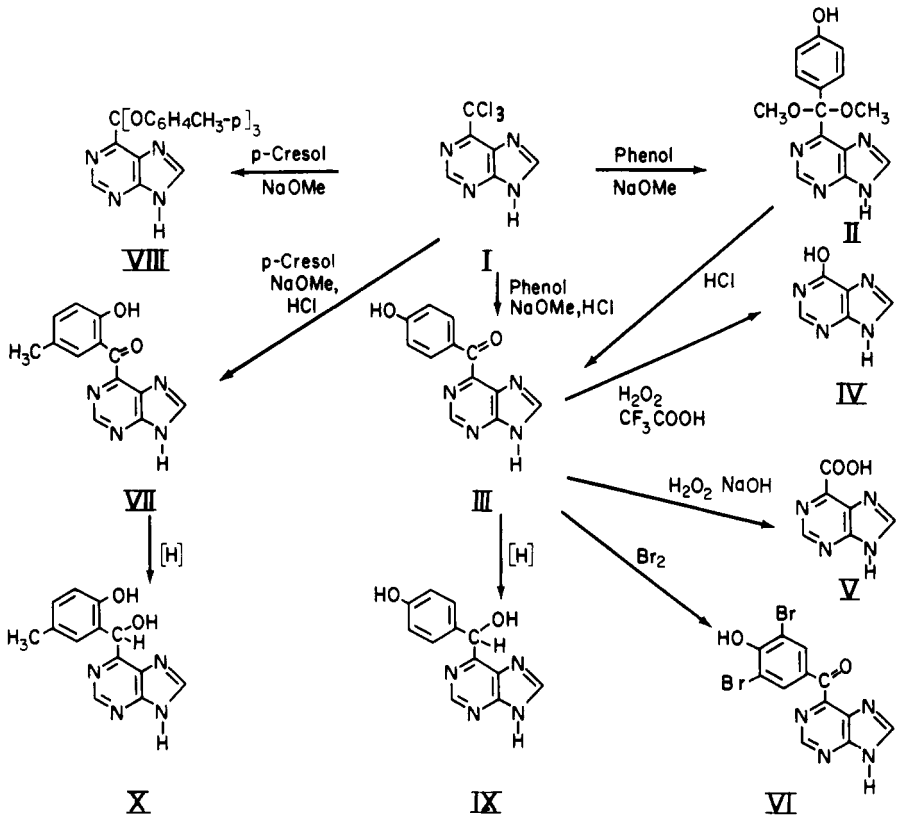
Oxidative degradation of III by the use of hydrogen peroxide in acetic or trifluoroacetic acid solution gave rise to hypoxanthine (IV); in sodium hydroxide solution, it gave rise to purinoic acid, V.[4] A boiling solution of sodium hydroxide had no effect on III, which means, therefore, that it was not a phenyl ester of purinoic acid. Finally, a solution of ferric chloride gave a blue color reaction with III suggesting the

(1) This investigation was supported by funds from the National Cancer Institute, National Institutes of Health, Public Health Service (grant no. CY-3190), the Atomic Energy Commission (contract no. AT[30-1], 910), and the American Cancer Society (grant no. T-128B).

(2) Visiting Research Fellow, on leave from the Israel Institute for Biological Research, Ness-Ziona, Israel.

(3) S. Cohen, E. Thom, and A. Bendich, *J. Org. Chem.*, **27**, 3545 (1962); proceedings of the 141st National Meeting of the American Chemical Society, Washington, D. C., March 21–29, 1962, abstract, page 23-N.

(4) The term "purinoic" has been proposed by the authors in an earlier publication [S. Cohen, E. Thom, and A. Bendich, *Biochem.*, **2**, 176 (1963)] to replace the less convenient purine-6-carboxylic.



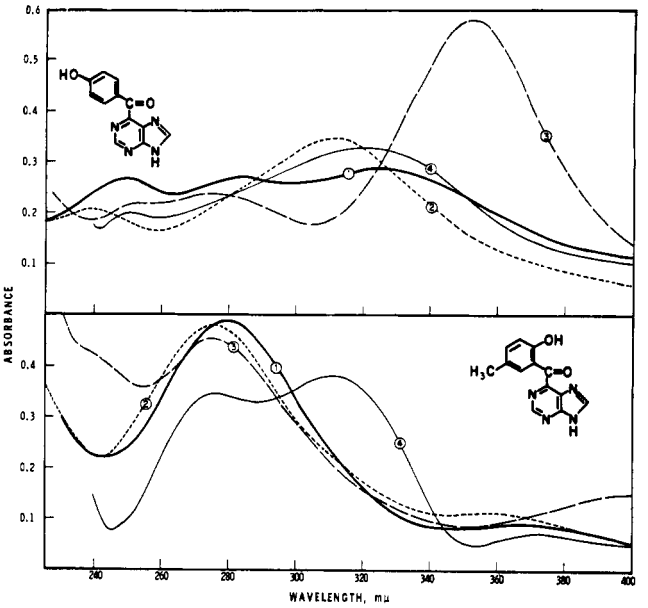
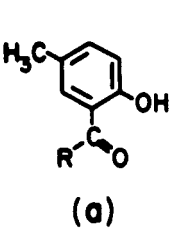


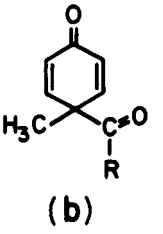
Fig. 1.—Ultraviolet absorption spectra of purin-6-yl 4-hydroxyphenyl ketone and purin-6-yl 2-hydroxy-5-methylphenyl ketone in (1) 1 *N* HCl; (2) 0.1 *M* phosphate buffer, pH 6.2; (3) 1 *N* NaOH; (4) chloroform. 1, 2, and 3 are equimolar, 4 arbitrary concentration.

presence of a phenolic grouping. This was also indicated by the action of bromine which gave the dibromo derivative (VI). In view of these observations, it was concluded that III has the structure of a purin-6-yl hydroxyphenyl ketone, the hydroxyl group being either *ortho* or *para* to the purinyl residue.

Reaction of I with *p*-cresol under analogous conditions gave rise to a yellow ketone, $C_{13}H_{10}O_2N_4$, VII, which differed markedly from III in its ultraviolet spectral properties (Table I, Fig. 1) and its greater solubility in organic solvents. Since the C-alkylation of *p*-cresol with chloroform under the conditions of the Reimer–Tiemann[5] reaction proceeds simultaneously at both the *para* and *ortho* positions to yield compounds of type (a) and (b) (R = H), VII may have either structure



(a)



(b)

(a) or (b) (R = purin-6-yl). However, the presence of a strong O—H stretching frequency in the infrared spectrum of VII, its color reaction with ferric chloride and its behavior on hydrogenation (see below) indicate structure (a) for this compound. Indeed, steric factors should not favor the formation of (b) which, in the case of chloroform, was obtained in low yield only.[6] A minor product of the reaction of I with *p*-cresol was 6-[tri(*p*-methylphenoxy)methyl]purine, VIII.

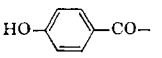
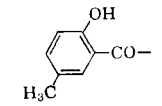
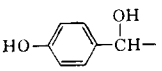
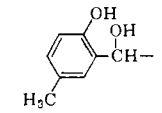
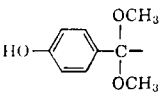
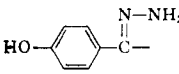
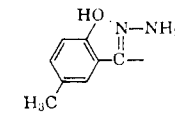
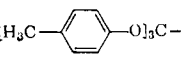
The ultraviolet spectral differences between III and VII can, therefore, be ascribed to a difference in the position of the hydroxyl group. Accordingly, in III the hydroxyl group should be *para* to the purinoyl residue. The ultraviolet absorption spectra of these two compounds are consistent with their assigned structures. In III, near coplanarity of the two ring systems and the cumulative effect of conjugated double bonds would be expected to have a pronounced effect on both the position and molar extinction of the maximum ab-

(5) For a comprehensive review of this reaction, see H. Wynberg, *Chem. Rev.*, **60**, 169 (1960).

(6) K. Von Auwers and G. Kiel, *Ber.*, **36**, 1861 (1903).

TABLE I

ULTRAVIOLET SPECTRAL PROPERTIES OF 6-SUBSTITUTED PURINES

Substituent	λ_{max}, mμ ($A_M \times 10^{-3}$) 1 *N* HCl	pH 6.2[a]	1 *N* NaOH
	325 (11.05) 285 (sh) (10.45) 248 (10.45)	310 (13.41) 240 (7.50)	352.5 (22.85) 275 (9.48) 250 (sh) (8.95)
	279 (11.94)	276 (11.84)	275.5 (10.75) 240–245 (sh) (9.82–9.34)
	264.5 (8.35)	268 (10.57)	278 (10.93) 240 (9.50)
	266 (8.83)	268 (9.72)	310 (sh) (3.69) 276 (9.28) 240 (sh) (8.15)
	264 (11.75)	273 (12.02)	280 (11.30)
	278 (9.18)	316 (10.16) 277 (11.15)	304 (12.60) 282 (sh) (11.85)
	360 (2.92) 266 (10.82)	318 (12.07) 277(11.20)	280 (11.50)
	271 (9.93)	276 (12.57)	278 (9.50)

[a] 0.1 *M* phosphate buffer.

sorbance. For the neutral species in water solution, λ_{max} is 310.5 and 240 mμ compared to 267 for purine-6-carboxaldehyde,[7] 280 mμ for purinoic acid,[8] 246 mμ for 4-hydroxybenzoic acid, and 248 and 289 mμ for 4-hydroxybenzophenone.[9] This effect is more noticeable in base (λ_{max}, 325.5 mμ: A_M 22,850), where loss of a proton would result in increased $n \rightarrow \pi$ transition in the conjugated system.

In VII, presence of the hydroxyl group at the *ortho* position is expected to hinder coplanarity of the two ring systems.[10] The two chromophores absorb almost independently of each other and the resulting ultraviolet spectrum is a mixture of their respective spectra.[11] In water solution, the neutral species exhibits a single maximum at 276 mμ. In nonpolar solvents, however, intramolecular hydrogen bonding between the hydroxyl group and the carbonyl oxygen may become more effective than in hydroxylic solvents. Such a bond implies coplanarity of the carbonyl group and the phenyl ring. The spectrum of VII in chloroform solution exhibits two peaks, at 312 and 277 mμ. It is interesting to compare these values to the corresponding ones for salicylaldehyde (258 and 331 mμ), salicylic acid (307 mμ), 2-hydroxybenzophenone (342 and 251 mμ),[9] and purine (263 mμ). The spectrum of III in chloroform is only slightly different from the one measured in aqueous solution.

Catalytic hydrogenation of III and VII in aqueous base and in presence of palladium on carbon proceeded slowly and stopped completely when about 1 mole of hydrogen was consumed per mole of ketone. The resulting carbinols, IX and X, retained their phenolic function as shown by the color test with ferric chloride and, in contradistinction to the parent ketones, displayed similar ultraviolet absorption spectra (Table I).

The mild conditions required for the acylation of phenols with I contrast sharply with the more drastic conditions required for chloroform in the Reimer–Tiemann reaction or for carbon dioxide in the Kolbe synthesis[12] of hydroxybenzoic acids. The same ease characterizes the reaction of I with alkoxide to yield ortho ester[3] or with amines to yield the corresponding N-purinoyl derivatives or, in case of aniline, N,N′-diphenylpurinylamidine.[13] In the closely related reactions with chloroform, there is strong evidence that di-

(7) A. Giner-Sorolla, I. Zimmerman, and A. Bendich, *J. Am. Chem. Soc.*, **81**, 2515 (1959).

(8) L. B. McKay and G. H. Hitchings, *ibid.*, **78**, 3511 (1956).

(9) J. VanAllan and J. F. Tinker, *J. Org. Chem.*, **19**, 1243 (1954); data are for spectrum in ethanol.

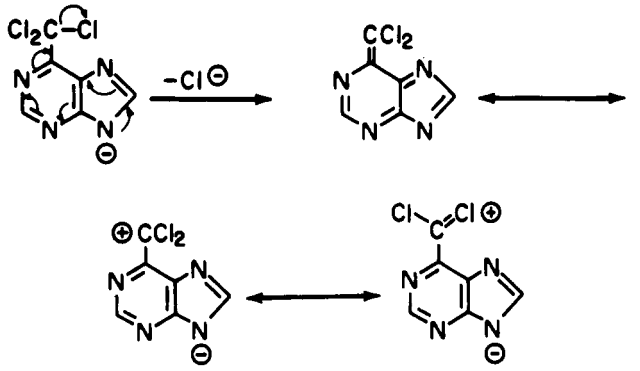
(10) E. A. Braude, F. Sondheimer, and W. F. Forbes, *Nature*, **173**, 117 (1954).

(11) The effect of restricted rotation on coplanarity and the ultraviolet spectral properties of the hindered compounds are reviewed and discussed by (a) A. E. Gillam and E. S. Stern in "An Introduction to Electronic Absorption Spectroscopy in Organic Chemistry," 2nd ed., Edward Arnold Ltd., London, 1957, p. 266; (b) E. A. Braude and E. S. Weight in W. Klyne's "Progress in Stereochemistry," Vol. 1, Academic Press, Inc., New York, N. Y., 1954.

(12) H. Kolbe, *J. prakt. Chem.*, **10**, 95 (1874).

(13) S. Cohen, E. Thom, and A. Bendich, *Biochem.*, **2**, 176 (1963).

chlorocarbene is the reactive intermediate involved.[14] Valency requirements, however, preclude formation of a carbene derivative from I. In an earlier study[13] on the acylation of amines by I, we advanced the view that the anion derived from I (pK_a, 7.93) may lose chloride far more rapidly than the neutral compound, giving rise to an uncharged, highly reactive intermediate, in which charge separation by resonance may con-



tribute slightly to the stability of the system. That such an intermediate may be involved in the various acylation reactions of I is supported by its close structural and electronic relation to the reactive ketene acetals.[15]

Experimental

Melting points were determined with a Thomas–Hoover apparatus. The R_f values are for ascending chromatograms on Whatman no. 1 paper, developed with the system *n*-butyl alcohol–formic acid–water (77:10:13 v./v.). The spectrophotometric measurements were made with a Cary Model 11 recording spectrophotometer at room temperature using 1-cm. quartz cells and a Perkin-Elmer Infracord spectrophotometer.

Reaction of 6-Trichloromethylpurine (I) with Sodium Phenoxide.—(a) A solution of phenol (0.5 g.) and I (1.2 g.) in 2 *M* methanolic sodium methoxide (10 ml.) was refluxed for 3 hr., then brought to dryness under partial pressure. The residue was redissolved in water (10 ml.) and the pH of the solution was adjusted to 5 by the addition of glacial acetic acid. A gummy precipitate was formed (0.5 g.). It was separated by decantation, dissolved in boiling acetone, and the solution was treated with charcoal, filtered, and brought to dryness. The residue was redissolved in boiling acetone. Upon addition of anhydrous ether, the hydrochloride of purin-6-yl 4-hydroxyphenyl ketone dimethyl ketal (II) precipitated; m.p. 230–235°, R_f 0.75. A solution of this compound in methanol gave a deep blue-green coloration with a trace of ferric chloride.

Anal. Calcd. for $C_{14}H_{15}O_3N_4Cl$: C, 52.1; H, 4.7; N, 17.3. Found: C, 52.5; H, 5.2; N, 17.3.

(b) A solution of I (2.4 g.) and phenol (3.8 g.) in methanolic 2 *M* sodium methoxide (40 ml.) was refluxed for 2 hr., then brought to dryness under partial pressure. The residue was dissolved in water (300 ml.) and the solution was acidified with hydrochloric acid and warmed, with stirring, to 50–60°. Purin-6-yl 4-hydroxyphenyl ketone (III), 1.9 g. (79%) was obtained as a yellow precipitate; m.p. 235–240° dec., R_f 0.75. A faint blue coloration was observed when a suspension of this compound in methanol was treated with a trace of ferric chloride.

Anal. Calcd. for $C_{12}H_8O_2N_4$: C, 60.0; H, 3.3; N. 23.3. Found: C, 60.2; H, 3.5; N, 23.1.

Infrared spectrum (KBr pellet): 3620, 3300, 3250, 3050, 2900, 2800, 2700, 1670, 1625, 1600, 1530, 1500, 1470, 1430, 1410, 1380, 1345, 1305, 1280, 1260, 1230, 1175, 1215, 1060, 1040, 970, 950, 910, 853, 822, 810, 775, 702, 683 cm.$^{-1}$.

The hydrazone of III was prepared by refluxing the compound for 2 hr. in excess anhydrous hydrazine, evaporation under reduced pressure, and recrystallization of the residue from aqueous ethanol; m.p. 285° dec.

Anal. Calcd. for $C_{12}H_{10}ON_6$: C, 56.6; H, 3.9; N, 33.1. Found: C, 56.8; H, 4.1; N, 33.5.

Oxidation of III.—(a) A solution of III (100 mg.) in 0.2 *N* sodium hydroxide (10 ml.) was treated with 30% hydrogen peroxide solution (2 ml.). The resulting yellow solution lost its color completely after 4 hr. at room temperature. Acidification with hydrochloric acid caused precipitation of purinoic acid (V) (50 mg., 73%); m.p. and m.m.p. with an authentic sample,[8] 200–202° with decarboxylation; λ_{max} 280 mμ (in water), R_f 0.27.

A paper chromatogram of a sample of the original oxidation mixture did not reveal the presence of any additional ultraviolet-absorbing product.

(b) A solution of III (100 mg.) in trifluoroacetic acid (10 ml.) was treated with 30% hydrogen peroxide solution (2 ml.). After 12 hr. at room temperature, the yellow color of the solution was almost discharged. The solvents were removed under reduced pressure, the residue was treated with water, and the resulting solution was evaporated to dryness. The gummy residue was then refluxed with acetone and the insoluble material (50 mg., 89%) separated by filtration. This was shown to be hypoxanthine (IV) by its characteristic ultraviolet absorption spectrum, R_f value on paper chromatograms, and its decomposition behavior on heating. A sample of the original oxidation mixture, subjected to paper chromatography, did not reveal the presence of any ultraviolet absorbing product in addition to hypoxanthine.

(c) A suspension of III (0.5 g.) in glacial acetic acid (10 ml.) was treated with 30% hydrogen peroxide (10 ml.) and the mixture was stirred at room temperature until III was almost dissolved (3 days). The solution was filtered from some unreacted material and brought to dryness under reduced pressure. The residue was taken up three times in ethanol and dried, and was finally recrystallized from excess cold aqueous ethanol to yield hypoxanthine (IV) (0.1 g., 35%) identified as stated above.

Catalytic Hydrogenation of III.—A solution of III (0.6 g.) in 5% aqueous ammonia (10 ml.) containing 5% palladium on carbon (0.1 g.) was shaken for 4 hr. under hydrogen at atmospheric pressure and room temperature. When about 55 ml. of hydrogen was absorbed, the solution was filtered and acidified with glacial acetic acid. (Purin-6-yl)(4-hydroxyphenyl)carbinol (IX) (0.4 g., 66%) crystallized and was purified by recrystallization from hot ethanol; m.p., 199–200°, R_f 0.61.

Anal. Calcd. for $C_{12}H_{10}O_2N_4$: C, 59.5; H, 4.1; N, 23.1. Found: C, 59.1; H, 5.0; N, 23.0.

Bromination of III.—A suspension of III (0.5 g.) in glacial acetic acid (10 ml.) was stirred and treated with bromine (*ca.* 0.2 ml.) at room temperature. The mixture was further stirred for 2 hr., the precipitate (0.5 g., 61%) was separated by filtration, washed with excess water, ethanol, and ether, and dried in air; m.p. above 320°.

Anal. Calcd. for $C_{12}H_6O_2N_4Br_2$: C, 36.2; H, 1.5; N, 14.1; Br, 40.2. Found: C, 36.8; H, 1.9; N, 14.5; Br, 37.6.

Reaction of I with *p*-Cresol.—(a) A solution of I (2.4 g.) and *p*-cresol (3.5 g.) in methanolic 2 *M* sodium methoxide (25 ml.) was refluxed for 2 hr., then brought to dryness under reduced pressure. The residue was taken up in water (50 ml.) and the solution acidified with hydrochloric acid. The resulting gummy precipitate was broken by stirring and warming the mixture. Purin-6-yl 2-hydroxy-5-methylphenyl ketone (VII) (1 g., 39%) was obtained as an orange precipitate, and was further purified by recrystallization from boiling methanol; m.p., 280–281° dec., R_f 0.84. A solution of the ketone VII in methanol gave a deep purple coloration with a trace of ferric chloride.

Anal. Calcd. for $C_{13}H_{10}O_2N_4$: C, 61.4; H, 3.9; N, 22.1. Found: C, 61.4; H, 4.1; N, 22.1.

Infrared spectrum (KBr pellet): 3620, 3200, 3120, 3030, 2930, 2890, 1750, 1650, 1610, 1600, 1570, 1495, 1470, 1420, 1400, 1380, 1345, 1330, 1310, 1280, 1250, 1220, 1170, 1155, 1140, 955, 925, 885, 830, 800, 790, 760, 700 cm.$^{-1}$.

The hydrazone of VII was prepared as described for III. It was recrystallized from aqueous ethanol; m.p., 239–240° dec.

Anal. Calcd. for $C_{13}H_{12}ON_6 \cdot 2H_2O$: C, 51.3; H, 5.5; N, 27.6. Found: C, 51.2; H, 5.3; N, 28.5.

(b) The reaction of I (2.4 g.) and *p*-cresol (3.5 g.) in 2 *M* methanolic sodium methoxide (25 ml.) was carried out as described (a). The gum was separated by decantation and taken up in hot methanol (100 ml.). Upon cooling, the methanolic solution deposited orange crystals, VII (0.5 g. 20%); the methanolic mother liquor was concentrated to a small volume, treated with charcoal, filtered, and diluted with water to yield

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0.2 g. (4%) of a white substance believed to be 6-[tri(4-methylphenoxy)methyl]purine (VIII); m.p. 214–215° dec., R_f 0.92.

Anal. Calcd. for $C_{27}H_{24}O_3N_4$: C, 71.4; H, 5.3; N, 12.7. Found: C, 71.9; H, 5.5; N, 12.2.

Compound VIII gave no color reaction with ferric chloride and could not be converted into VII by treatment with 1 *N* hydrochloric acid for 30 min. at 60–70°.

Catalytic Reduction of VII.—A solution of VII (0.55 g.) in 5% aqueous ammonia (50 ml.) containing 5% palladium on carbon (50 mg.) was shaken for 4 hr. under hydrogen at atmospheric pressure and room temperature. The total volume of hydrogen absorbed was about 62 ml. The solution was filtered and evaporated to dryness under reduced pressure. The residue (0.5 g., 91%) was recrystallized from methanol to yield pure (purin-6-yl)(2-hydroxy-5-methylphenyl)carbinol (X); m.p. 233–234° dec., R_f 0.70. The carbinol gave an intense blue coloration with a trace of ferric chloride in methanol.

Anal. Calcd. for $C_{13}H_{12}O_2N_4$: C, 60.9; H, 4.7; N, 21.9. Found: C, 60.8; H, 5.2; N, 21.8.

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Notes

Preparation of 4,5-Dihydroöxepine and 1,2-Divinylethylene Oxide

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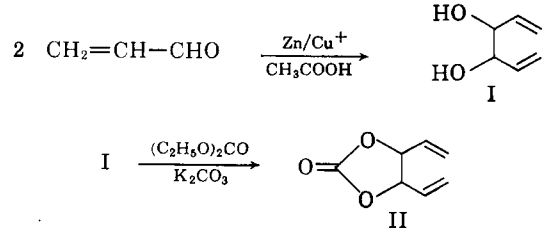
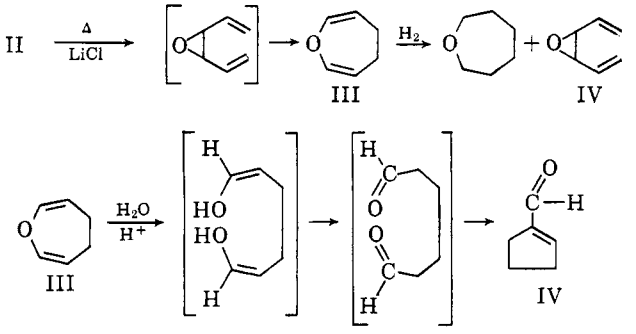
In recent years several examples of unsaturated derivatives of seven-membered heterocyclic systems have been reported[1–6] and have been of interest because of the possibility of planarity and aromatic stability. We wish to report a three-step synthesis of the new compounds, 4,5-dihydroöxepine (III) and 1,2-divinylethylene oxide (3-epoxy-1,5-hexadiene) (IV), as well as a new example of valence isomerism of a strained ring compound.[7] 1,5-Hexadiene-3,4-diol (I) is conveniently prepared by the bimolecular reduction of acrolein through the influence of a zinc–copper couple. *sym*-divinylethylene carbonate (II) was obtained in high yield from the reaction of (I) with diethyl carbonate using potassium carbonate as catalyst.



The lithium chloride-catalyzed pyrolysis of II at 200° was expected to give one or both isomers of 1,2-divinylethylene oxide. The constant boiling pyrolysate was separated into two fractions by preparative scale vapor phase chromatography.

The first fraction was shown to be one of two steric forms of 1,2-divinylethylene oxide (IV) and, on the basis of known relative stabilities of *cis*- and *trans*-divinylcyclopropanes,[8,9] we believe the *trans* form was isolated. The other fraction was identified as 4,5-dihydrooxepine (III) and presumably resulted from the Cope rearrangement of the less stable *cis* isomer 1,2-divinylethylene oxide.

The infrared, near-infrared, ultraviolet, and nuclear magnetic resonance spectra of III are consistent with the structure assigned. Hydrogenation of 4,5-dihydrooxepine resulted in the uptake of two moles of hydrogen, and reaction of (III) with aqueous acetic acid and 2,4-dinitrophenylhydrazine reagent results in the formation of the corresponding hydrazine derivative of 1-cyclopentene carboxaldehyde (V).



1-Cyclopentene carboxaldehyde presumably results from the acid-catalyzed hydrolysis of III to adipaldehyde which readily undergoes an internal Aldol condensation to give V.[10]

Experimental

1,5-Hexadiene-3,4-diol (I).—Compound I is obtained by the bimolecular reduction of acrolein with zinc–copper couple and acetic acid using the method described previously for the reduction of crotonaldehyde.[11] Compound I is a colorless liquid, b.p. 55° (0.2 mm.), $n^{25}D$, 1.4739, d^{25}_4 1.0097, which has been prepared previously only in 20–30% yields.[12] The yield can be improved to above 90% by using an ether such as tetrahydrofuran or dioxane as solvent instead of water.

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