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Purine *N*-Oxides. LX. The Photoreactions of 6-Methyl- and 6,9-Dimethylpurine 1-Oxides[1]

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Received November 14, 1974

Abstract: The photochemistry of 6-methyl- and 6,9-dimethylpurine 1-oxides was investigated to evaluate the role of tautomerism and the influence of reaction medium on the reaction pathways. Products resulting from rearrangement, reduction, and ring opening were identified. The extent of each type of reaction and the manner of ring opening varied with the photolysis conditions, but not in a uniform manner for both compounds. The data do not indicate a contribution by an *N*-hydroxy tautomer in the photochemistry of these compounds. The greatly enhanced extent of ring opening in acid media, which occurs at the expense of photorearrangement, indicates that protonation of an intermediate common to both processes increases the proportion that follows the former pathway. This is the first indication of the presence of an intermediate in the photorearrangement of aromatic amine *N*-oxides. A unifying mechanism is proposed for the formation of ureido- and nitrile-substituted imidazoles from purine 1-oxides. Studies with paramagnetic ionic triplet quenchers show that photoreduction of these purine *N*-oxides involves a triplet intermediate.

The facile photochemical formation of radicals in the solid state of *N*-hydroxypurines[2] and the possible association of radicals from such compounds with their oncogenic potential[3] encouraged a more detailed examination of the photochemistry of *N*-oxidized purines.[4,5] An earlier study examined the influence of tautomeric and ionic states on the photochemistry of *N*-hydroxyhypoxanthines,[4] which were selected as models of compounds whose neutral forms exist as the *N*-hydroxy tautomer. The similarity in behavior and structure of the anions of such compounds to aromatic *N*-oxides was noted[4] and we now report a study of the photochemistry of two purine *N*-oxides in which the *N*-oxide form should be the predominant or the exclusive tautomer.

Photolysis of 6-Methylpurine 1-Oxide (1) (Table I). The p*K*'s associated with protonation and ionization of **1**[6] are 1.18 and 7.51.[7] Irradiation of the neutral molecule (pH 3.0) produced 6-methylpurine (**3**, 5%), 6-methyl-2-hydroxypurine (**5**, 20%), and 4-amino-5-acetylimidazole (**7**, 32%) (Scheme I, Table I). Irradiation of the anion of **1** at pH 9.5 gave 5% of **3** and 31% of **5** but no **7**. From irradiations of **2** in CH_3OH or CH_3CN solution, the only uv-absorbing products detected were **3** and **5**, which were obtained in nearly equal amounts (9%).

Photolysis of 6,9-Dimethylpurine 1-Oxide (2). The p*K* of protonation of **2** was found to be 1.20 ± 0.06. Irradiation of **2** at pH's 3.0, 6.0, or 10 (Tables II and III) yielded approximately equal amounts (10–12%) of 6,9-dimethylpurine (**4**) and 6,9-dimethyl-2-hydroxypurine (**6**) as the major photoproducts. The latter has not previously been reported and its identity was confirmed by independent synthesis. In addition to **4** and **6**, 4-acetyl-5-amino-1-methylimidazole (**8**) was obtained from the irradiations of **2** at pH's 0 (3 *N* CF_3CO_2H) and 3.0. The *N*-oxide, **2**, was stable in these solvents at room temperature in the absence of light, but could be hydrolyzed to **8** under more vigorous conditions. In nonaqueous solvents the irradiation of **2** gave less than 1% of **4** and ca. 9% of **6**. When **2** was irradiated in methanol or ethanol solution, a new compound, 1-methyl-4-acetyl-5-ureidoimidazole (**9**) was obtained. The ureide undergoes rapid ring closure to **6** in alkaline solution, which complicated at-

Table I. Photolysis of 6-Methylpurine 1-Oxide[a]

Expt No.	Solvent	pH	Time[b]	3, %	5, %	7, %	1, %	Recovery, %[c]
1	H_2O	3.0	30	5	20	32		57
2	H_2O	9.5	30	5	31		15	51[d]
3	CH_3OH		15	9	7		6	22
4	CH_3CN		15	9	9			18

[a] Irradiations were performed under N_2 with a high pressure Hg lamp and a Pyrex filter. [b] Minutes. [c] Expressed as percent of starting material. [d] A small amount of a third, unidentified product could be detected.

Table II. Photolysis of 6,9-Dimethylpurine 1-Oxide[a]

Expt No.	Solvent	pH	Time[b]	4, %	6, %	2, %	8, %	9, %	Recovery, %
5	H_2O	0	60	11%	3	0	55	0	69[c]
6	H_2O	3.0	60	9	14	0	6	0	29[c]
7	H_2O	10	60	10	10	0	0	0	20[c]
8	CH_3OH		15	1	8	13	0	23[d]	45
9	C_2H_5OH		15	1	9	13	0	23[d]	46
10	CH_3CN		15	1	9	14	0	0	24[c]

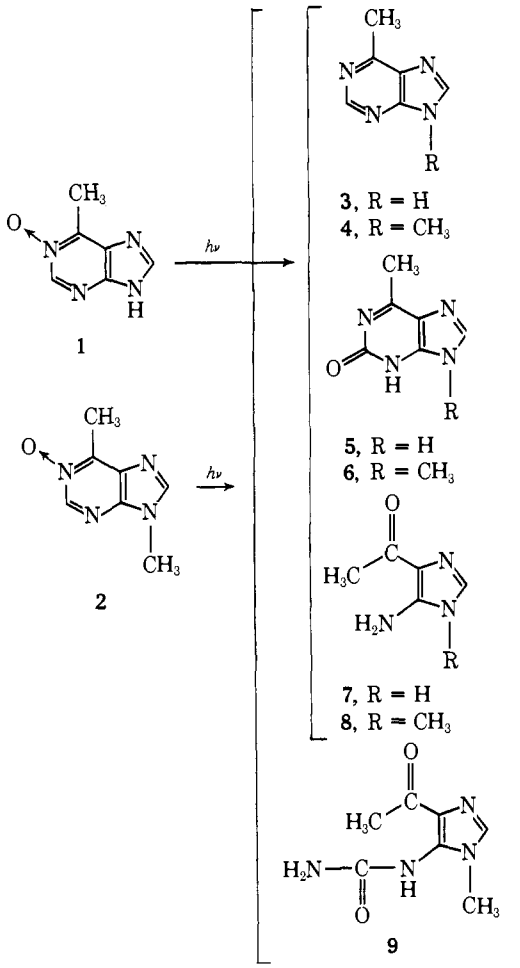
[a] High pressure Hg lamp with N_2 flushing and Pyrex filter. [b] Minutes. [c] An unidentified compound was present whose uv absorption manifests end absorption in both acid and base. [d] These values were determined by conversion of the ureide, 9, to **6** with base and calculation of molar quantities from the known ϵ of 6.

Table III. Quenching Study of 2 in Aqueous Solution[a]

Expt No.	Time, min	Quencher (M)	4, %	6, %	8, %	2, %
11	60	None[b]	11	10	0	4
12	60	Ni^{2+}[c] (0.0203)	0	11	37	8
13	60	Ni^{2+} (0.0041)	0	13	25	5
14	60	Cu^{2+}[d] (0.0175)	0	11	28	7
15	60	Cu^{2+} (0.0035)	0	13	38	10
16	60	Mn^{2+}[e] (0.0204)	9	10	0	3

[a] Irradiations were performed in a Rayonet Photochemical Reactor equipped with 3000 Å lamps and a Merry-Go-Round apparatus with ca. 2.2×10^{-3} M solution of **2**. [b] pH 6.0. [c] $NiSO_4 \cdot 6H_2O$. [d] $CuCl_2 \cdot 2H_2O$. [e] $MnCl_2 \cdot 4H_2O$.

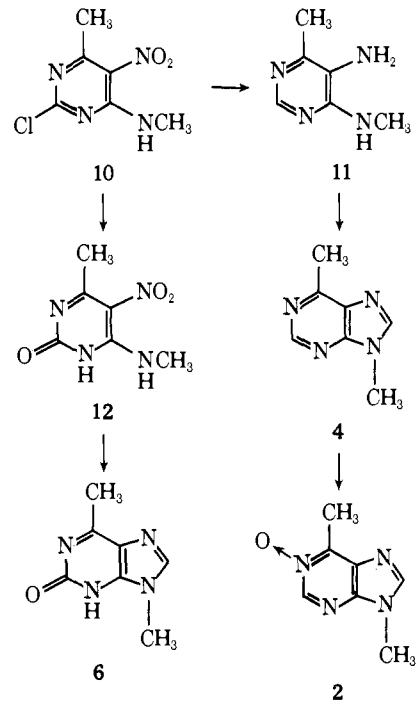
Scheme I



tempts to isolate and purify a sample of **9** for identification. Its structure could be assigned from its mass spectrum. Attempts to obtain **9** by reacting **8** with KCNO were not successful.

Synthesis. The methylation of 6-methylpurine (**3**) to 3,6- and 6,9-dimethylpurine (**4**) and a total synthesis of **4** have been reported.[8] An improvement in the synthesis of **4** was realized by the direct catalytic reduction of 2-chloro-4-

Scheme II



methylamino-5-nitro-6-methylpyrimidine (**10**) (Scheme II) to 4-methylamino-5-amino-6-methylpyrimidine (**11**).[9] This eliminates two steps from the earlier synthesis and affords a nearly quantitative yield of **11**, which readily undergoes ring closure to **4**.

Peroxyacetic acid oxidation of **4** gave only 6,9-dimethylpurine 1-oxide (**2**). The position of oxidation can be assigned unambiguously by the similarity both of its uv spectra and of its pK of protonation to the corresponding values for **1**.[7] The differences between the uv and pK values of the 1- and 3-oxides of **3** have been discussed.[7]

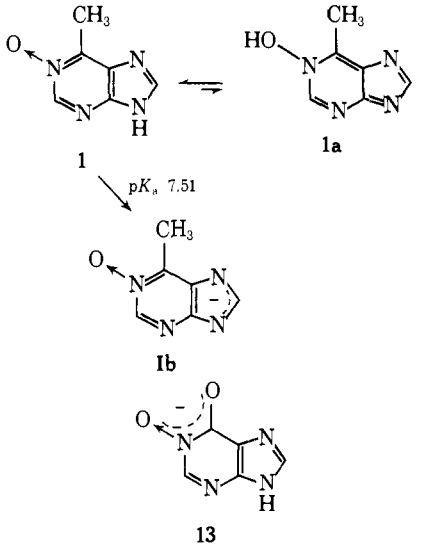
For confirmation of the structure of the rearrangement product from **2**, an authentic sample of 2-hydroxy-6,9-dimethylpurine (**6**) was prepared (Scheme II) by displacement of the 2-chloro substituent of **10** to yield 2-hydroxy-4-methylamino-5-nitro-6-methylpyrimidine (**12**) followed by reduction of the 5-nitro group and ring closure. Synthetic **6** and the photoproduct from **2** showed identical uv and chromatographic properties.

Discussion

Uv irradiation of heterocyclic N-oxides induces rearrangements, most frequently of the oxygen from nitrogen to the adjacent carbon, reduction to the parent purine, and in some instances ring opening.[10-13] Rearrangement and reduction were reported to occur to nearly equal extents for adenine 1-oxide and 6-methylpurine 1-oxide (**1**).[11] This degree of photoreduction is much higher than usually observed for most heterocyclic N-oxides.[10] Previously photoreduction was reported to be the major process of the N-

hydroxy tautomer of 1-hydroxyhypoxanthine, but was a minor result, relative to rearrangement, with the enolate anion, **13**[4] (Scheme III). While it has been assumed that

Scheme III



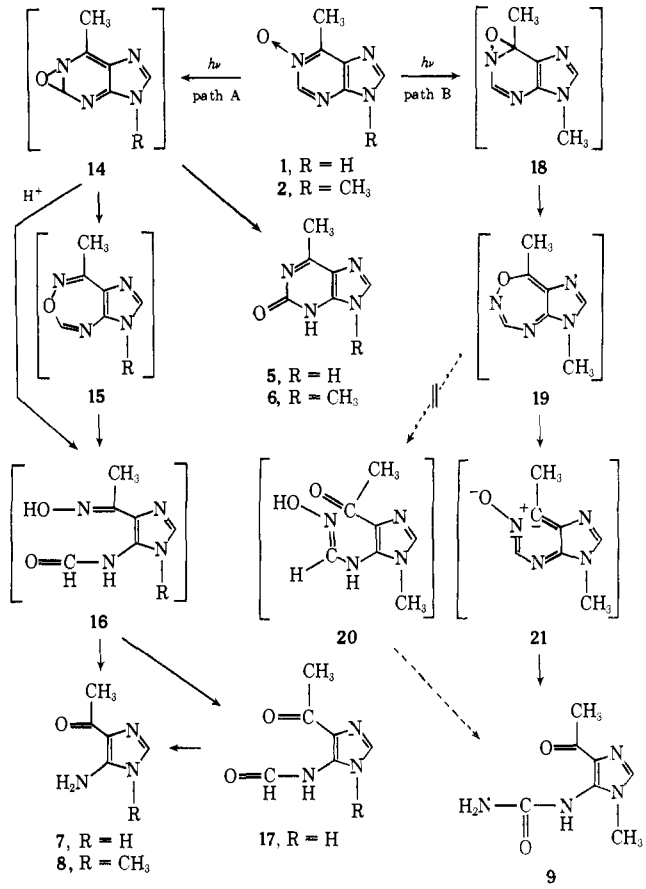
the 1-oxides of adenine and adenosine exist largely as the *N*-oxide tautomer,[14] the high degree of photoreduction and the increase in photorearrangement observed at higher pH for the latter[13] suggested that an *N*-hydroxy species might play a role in the photochemistry of these compounds. The 1-oxide group is known to enhance the acidity of the 6-amino group, relative to that of the parent purines, and pK_a's of ca. 15 and 12.86,[14,15] respectively, have been recorded for these *N*-oxides. It has been suggested that this ionization is associated with the presence of some *N*-hydroxy tautomer for these compounds.[15] No corresponding ionization from the 6 substituent is expected for **1**,[7] but the extensive photoreduction reported[11] for **1** suggested that an alternative *N*-hydroxy tautomer, **1a** (Scheme III), might be possible in an excited state of **1**. To test this possibility and to study the photochemistry of the purine 1-oxide system in the absence of a tautomeric equilibrium, 6,9-dimethylpurine 1-oxide (**2**) was prepared and its photochemistry is compared to that of **1** (Tables I and II).

Ionization of **1** must occur from the imidazole to form **1b** (Scheme III). The strong absorption band near 230 nm at pH 3, for the neutral species, and at pH 9, for the anion, has been interpreted as evidence for the predominance of the *N*-oxide form in both species.[7] The loss of this absorption in acid indicates that protonation of **1**, pK = 1.18, occurs on the oxygen.[7]

Irradiation of the neutral species of **1** at pH 3 gave 6-methylpurine (**3**) (5%), 2-hydroxy-6-methylpurine (**5**) (20%), and 4-acetyl-5-aminoimidazole (**7**) (32%). Two additional photoproducts were also detectable from a Bio-Rad A-6 (NH_4^+) column. Both compounds were immediately hydrolyzed to **7** in acid and each proved too labile for isolation. From the position of elution on a standardized A-6 column and uv absorption data, the structure of one of these precursors of **7** can be assigned as 4-acetyl-5-formylaminoimidazole (**17**) (Scheme IV).[16] Irradiation of the anion of **1** at pH 9 gave more **5** (30%), no change in the yield of **3**, and no **7**.

Only one tautomeric form is possible for **2** and, not unexpectedly, similar yields of photoisomerization and deoxygenation products were obtained at pH's 3, 6, and 10 (Table II). A small yield (6%) of 1-methyl-4-acetyl-5-aminoimidazole, **8**, was also obtained from the irradiation of **2** at pH 3.

Scheme IV



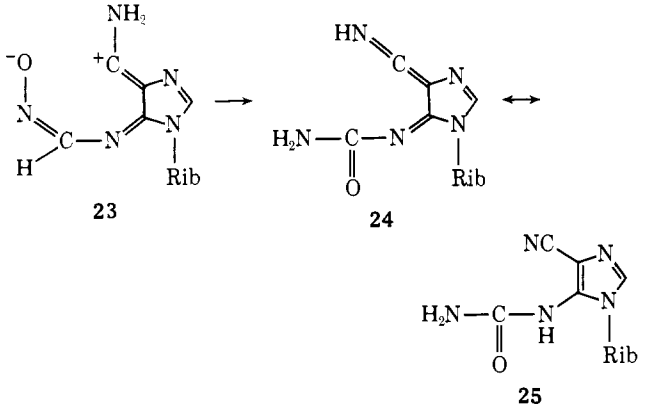
The photoinduced migration from N to C of the oxygen of heterocyclic *N*-oxides is presumed to occur via a transient oxazirane intermediate,[10,17] e.g., **14** (Scheme IV). An alternative reaction path, ring expansion, is also possible for **14**.[10] Path a (Scheme IV) illustrates the oxazirane precursor, **14**, of the 2-hydroxy-6-methylpurines and the oxadiazepine, **15**, that would result from ring expansion of **14**. Opening of ring-expanded intermediates, such as **15**, has been proposed to explain the formation of some photoproducts of *N*-oxides.[18] Hydrolysis of **15** would account for the formation of the aminoacetylimidazoles, **7** and **8**, observed from the photolysis of **1** and **2**, but an alternative explanation appears to be more in accord with the present data. It is evident that acid diverts the photoreaction of **1** and **2** from rearrangement to the 2-hydroxypurines, **5** or **6**, to a process leading to ring-opened imidazoles, **7** or **8**, since these are observed only from irradiations in acidic solutions. Even at pH 3, **7** is a major product (32%) from **1**, while **8** is a significant product (6%) from **2**. This effect of acid on the course of photoreactivity of **2** is more apparent from the irradiation at pH 0, where **8** becomes the major product (55%). Significantly, this occurs in part at the expense of rearrangement to **6**, the yield of which decreases from 14 to 3%, while the amount of photoreduction to **4** was not affected. Under the conditions of irradiation, **6** is slightly decomposed (80% recovery) but does not yield **8**, while without irradiation **2** is only slowly hydrolyzed to **8**. These results indicate that there is a common intermediate for **5** and **7** (or for **6** and **8**) and that protonation of this intermediate reduces photoisomerization and increases ring opening. The common intermediate must be **14**, rather than **15**, since **15** cannot be an intermediate in the formation of **5** or **6**. This suggests that in acid **7** and **8** arise not by hydrolysis or photolysis of **15** but by direct acid catalyzed hydrolysis of **14**.[19] These data provide the first indication of a transition inter-

mediate in the photorearrangement of *N*-oxides and are consistent with an oxazirane intermediate.

The nature of the solvent has been reported to exert an influence on the photochemistry of *N*-oxides[10] and this was also observed for **1** and **2**. The amount of photoreduction remained constant for each compound at all pH values in aqueous solution. In nonaqueous media, whether hydroxylic or not, photoreduction was enhanced for **1**, but nearly eliminated for **2**. The higher extent of reduction of **1** in solvents of lower polarity would be consistent with a tautomeric *N*-oxide-*N*-hydroxyl equilibrium, e.g., **1** and **1a** (Scheme III), since the *N*-hydroxy form should be favored in the less polar organic solvents.[23] No such equilibrium is possible for **2**, hence the extent of photoreduction of **2** would be expected to be the same under all conditions. This was not the case. Since the magnitude of the solvent effect for **2** is comparable to that for **1**, the contribution, if any, of an *N*-hydroxy tautomer to the photochemistry of **1** cannot be assessed.

A second effect on the photochemistry of **2** by the medium was the production of 1-methyl-4-acetyl-5-ureidoimidazole (**9**) from the irradiation of **2** in alcohol solutions only. The structural features of **9** are such that it cannot arise from the oxazirane, **14**, and the yield of the product, **6**, from **14** was not affected by the production of **9**. The formation of **9** may be reasonably explained by formation of the isomeric oxazirane,[25] **18** (path b, Scheme IV), and ring expansion of **18** to the imidazolooxadiazepine, **19**. Two routes are conceivable for the formation of **9** from **19**, hydrolysis of **19** to **20**, or photolysis of **19** to **21**, followed by photorearrangement of the formamidoxime moiety of **20** or **21** to the ureide of **9**. While photoisomerization of oximes to the corresponding amides is known,[29,30] the corresponding rearrangement of amidoximes to ureas has not been described. To test whether such a rearrangement was possible, *N*-phenylformamidoxime (**22**)[31] was irradiated in alcohol solution. It was converted to several products, but did not yield phenylurea. This suggests that formation of **9** is not preceded by hydrolysis to **20**, but instead may proceed by direct photolysis of **19** to **9**. 1-Ribosyl-4-cyano-5-ureidoimidazole (**25**) (Scheme V) was previously isolated from the irradiation of

Scheme V



Rib = β-D-ribofuranosyl

adenosine 1-oxide.[13] It is noteworthy that a cyano derivative was obtained. The 4-carboxamide would be expected if the product arose by hydrolysis of the imidazolooxadiazepine comparable to **19** and subsequent photorearrangement of the formamidoxime group of the intermediate analogous to **20**. This agrees with the evidence which suggests that photolysis of **19** induces a heterolytic cleavage of the N-O bond to **21** (Scheme IV) and subsequent rearrangement of the formamidoxime anion thus formed[33] to the ureide moiety of **9**. Reaction of the carbonium portion of **21** with alcohol and hydrolysis of the vinyl ether would afford the acetyl moiety of **9**. An analogous sequence of reactions from **23** (Scheme V) would yield the ureido group of **25**. Formation of the nitrile group of **25** is also readily accommodated by this mechanism, since loss of a proton from the amino group adjacent to the carbonium ion of **23** would yield the imine **24**, which is a tautomer of the product **25**. Thus, heterolytic photolysis of the N-O bond in imidazolooxadiazepines, such as **19**, provides a unifying explanation for the formation of ureidoimidazoles from purine 1-oxides and for the unexpected nitrile substituent of **25**.

Quenching Study. The available evidence on the nature of the excited states that lead to the various photoproducts from aromatic *N*-oxides suggests that photoreduction proceeds from the triplet, while rearrangement is a singlet process. Some of the evidence has been questioned[26] since part of it rests on the observed decrease in deoxygenation in the presence of oxygen,[10,27,34] which is assumed to quench the triplet, but this effect by oxygen is not uniformly observed.[26,34] Other studies used triplet sensitizers[27,35] but did not consider the possibility of chemical sensitization[36] by ketyl radicals. Reduction by ketyl radicals was found to be a significant contributor in the sensitized photoreduction of *N*-hydroxypurines[4] and of azoxybenzene.[37] An alternative approach to the elucidation of excited states is the use of paramagnetic ions as triplet quenchers.[38,39] This method is particularly useful for **2** since photoreduction of it is maximal in aqueous solutions. Irradiation of **2** in the presence of $CuCl_2$ or $NiSO_4$ (Table III), both efficient triplet quenchers,[39] eliminated photoreduction, while $MnCl_2$, a weak quencher, had no effect on photoreduction. Since the uv spectrum of **2** was not altered by the presence of these ions, the results are unlikely to be due to photoreactions of ion complexes with **2**. The data are consistent with quenching of the triplet and indicate that photoreduction of **2** proceeds from the triplet. This conclusion agrees with the observation of enhanced deoxygenation of pyridine *N*-oxides in the presence of heavy atom solvents.[26]

There was also a substantial increase in ring opening of **2** to **8** in the presence of Cu^{2+} and Ni^{2+},[40] but not with the weak triplet quencher Mn^{2+}. An increase in ring opening would not be anticipated to result from triplet quenching of **2** by these ions, but must instead be associated with an effect of the ions on a precursor of **8**, such as **14** or **15**. The product **6** was stable under these photolysis conditions. Since the yield of **6** was not affected by the presence of the ions, in contrast to the effect of acid, the enhanced formation of **8** must not be the result of an interaction of the ions with **14**. This suggests that the ions react with **15**. They are excellent catalysts for the hydrolysis of glycosides[42] and the enhanced formation of **8** may be due to catalytic hydrolysis of **15** to **8** before **15** can undergo additional photoreactions that result in degradation and loss of uv absorption. This would also explain the higher recoveries in the presence of the ions.

Quantum Yields. The quantum yields of disappearance of **1** and **2** were determined by potassium ferrioxalate actinometry by methods described[43] and found for **1** to be 3.5×10^{-3} at pH 3.3 and 4.4×10^{-3} at pH 10.5. For **2** the quantum yield at pH 6 was 3.7×10^{-3}.

Experimental Section

General. Uv spectra were determined with a Unicam SP800A recording spectrophotometer and nmr spectra with a Varian A-60 or a Jeol 100 Hz spectrometer. Direct photolyses were carried out with a Hanovia 450-W high pressure Hg lamp. The quenching study was performed in a Rayonet photochemical reactor equipped with 3000-Å lamps and a Merry-Go-Round apparatus. All solu-

tions were flushed with a stream of N_2 for at least 30 min prior to irradiation. Elemental analyses were performed by Spang Microanalytical Laboratory, Ann Arbor, Mich. Paper chromatograms were developed, ascending, on Whatman No. 1 paper with the following solvent systems: (A) CH_3CN-H_2O (3:1, v/v) and (B) CH_3CN-H_2O-28% NH_4OH (7:2:1).

Chromatography. Photolysis products were separated with a BioRad AG-50 × 8 (H^+), 200-400 mesh, column (9 × 220 mm) that was monitored with an ISCO UA-4 UV-Analyzer at 254 and 313 nm. The column was eluted with 1 *N* HCl and products were eluted in the sequence: **5**, **1**, **3**, and **7** from photolyses of **1** and **9**, **6**, **8**, **2**, and **4** from photolyses of **2**. Yields of photoproducts were calculated from ϵ_{max} values. The λ_{max} (ϵ_{max}) values at pH 0 were determined to be 292 nm (7300) for **8**, 265 (6200) for **4**, 273 (5150) for **2**, 316 (7260) for **6**, 245 (8670) for **9**, 292 (6350) for **7**. Values have been reported for **1** (275 nm, 5200),[7] **3** (265 nm, 7600),[44] and **5** (318 nm, 8130).[45]

4-Methylamino-5-amino-6-methylpyrimidine (12). A sample of 2-chloro-4-methylamino-5-nitro-6-methylpyrimidine (**11**)[46,47] (5.0 g, 2.5 mmol) in 100 ml of absolute ethanol and 2.0 ml of 28% NH_4OH was hydrogenated at atmospheric pressure with 2.0 g of 5% Pd/C. The uptake of hydrogen stopped after 3 hr. The solution was filtered and the filtrate was evaporated to dryness in vacuo to afford 3.3 g (97%) of pure **12** that had identical properties to those described[6] for **12**.

6,9-Dimethylpurine (4). A solution of **12** (3.3 g, 2.4 mmol) in 100 ml of 97-100% formic acid and 10 ml of acetic anhydride was heated under reflux for 2 hr. The solvent was then evaporated under reduced pressure and the residue was extracted with three 100-ml portions of $CHCl_3$. The combined extracts were treated with charcoal and pure 6,9-dimethylpurine was isolated by elution of the sample from a neutral alumina column (2.5 × 45 cm) with $CHCl_3$, yield 2.5 g (64%). This sample was identical with a sample prepared by methylation of 6-methylpurine, as described.[8]

6,9-Dimethylpurine 1-Oxide (2). 6,9-Dimethylpurine (0.55 g, 0.34 mmol) was stirred with 10 ml of HOAc and 5 ml of 30% H_2O_2 at room temperature for 5 days and the progress of the reaction was followed by paper chromatography in solvent **B**; **2**, R_f 0.25; **4**, R_f 0.68. The mixture was then concentrated to a small volume in vacuo and extracted twice with small amounts of ethyl acetate. The extracts were discarded and the residue was purified by dissolving the sample in methanol, treating the solution with charcoal, and filtering. Slow addition of ethyl acetate to the methanolic solution until the solution became cloudy and chilling the solution gave a colorless precipitate. This was collected and dried in vacuo to give pure 6,9-dimethylpurine 1-oxide: yield 0.20 g (32%); mp 125°; $pK_a = 1.20 \pm 0.06$;[49] uv λ_{max} (ϵ) (pH −1.0) 215 nm (26.0×10^3), 273 (5500) and (pH 7.0) 233 nm (20.7×10^3), 258 (4800), 313 (4000); NMR (DMSO-d_6) δ 2.65 (s, 3, CCH_3), 3.85 (s, 3, NCH_3), 8.22 (s, 1), 8.65 (s, 1); mass spectrum *m/e* 164 (M), 148 (M − 16), 147 (M − 17), 120 (M − 44).

Anal. Calcd for $C_7H_8N_4O \cdot \frac{1}{8}H_2O$: C, 50.52; H, 4.99; N, 33.66. Found: C, 50.30; H, 4.94; N, 33.58.

2-Hydroxy-4-methylamino-5-nitro-6-methylpyrimidine (13). A solution of **11** (2.0 g, 10 mmol) in 10 ml of 1 *N* NaOH was stirred in a H_2O bath for 2 hr. The solution was neutralized with 1 *N* HCl and a single product was isolated from a 9 × 130 mm, AG-50 (H^+), 200-400 mesh column, by eluting with 1 *N* HCl. Analytically pure **13** was obtained after the solid was washed with ethanol and dried in vacuo: yield 0.70 g (38%); mp 246-249°; NMR (DMSO-d_6) δ 2.54 (s, 3, CCH_3), 2.90 (d, 3, $J = 4$ Hz, NCH_3).

Anal. Calcd for $C_6H_8N_4O_3$: C, 39.13; H, 4.38; N, 30.42. Found: C, 38.91; H, 4.32; N, 30.46.

2-Hydroxy-6,9-dimethylpurine (6). A sample of **13** (500 mg, 2.71 mmol) in 80 ml of 97% formic acid and 50 mg of 10% Pd/C was hydrogenated at atmospheric pressure. The uptake of hydrogen stopped after 2 hr. The solution was filtered, then 2 ml of acetic anhydride was added to the filtrate and the mixture was heated to reflux for 3 hr. An analytical AG-50 (H^+) column showed only a small amount of starting material remained. The solution was evaporated to dryness in vacuo. 2-Hydroxy-6,9-dimethylpurine (**6**) was isolated by chromatography over an AG-50 (H^+) column (25 × 120 mm) by elution with 1 *N* HCl: yield 220 mg (49%); mp >300° dec; uv λ_{max} (ϵ) (pH 0) 214 nm (24,200), 236 (2200), 316 (7260) and (pH 12) 219 nm (22,200), 240 (4160), 304 (9250); NMR (D_2O) δ 2.83 (s, 3, CCH_3), 3.87 (s, 3, NCH_3), 8.55 (s, 1, C_8H).

Anal. Calcd for $C_7H_8N_4O$: C, 51.21; H, 4.91; N, 34.13. Found: C, 51.00; H, 4.68; N, 33.97.

1-Methyl-4-acetyl-5-aminoimidazole (8). 6,9-Dimethylpurine 1-oxide was hydrolyzed by heating a solution of 20 mg (0.12 mmol) in 10 ml of 1 *N* HCl to reflux for 20 min. The uv spectrum showed a change from 276 nm to 291 nm. A crude product (18 mg) was isolated from a 9 × 200 mm AG-50 (H^+) column by elution with 1 *N* HCl. The yellow solid was dissolved in 25 ml of hot ethanol, treated with charcoal, and filtered. After evaporation of the solvent pure **8** (12 mg, 56%) was obtained: mp 170° dec; uv λ_{max} (ϵ) (pH 0) 292 nm (8000) and (pH 12) 300 nm (12,400); NMR (DMSO-d_6) δ 2.40 (s, 3, CCH_3), 3.57 (s, 3, NCH_3), 7.40 (broad, 2, NH_2), 8.20 (s, 1, CH).

Anal. Calcd for $C_6H_8N_3O \cdot HCl \cdot H_2O$: C, 35.45; H, 5.90; N, 20.60. Found: C, 35.88; H, 5.93; N, 20.50.

1-Methyl-4-acetyl-5-ureidoimidazole (9). A sample of **9** was obtained by irradiating 95 mg of **2** in 250 ml of absolute EtOH for 60 min, evaporating the solvent under reduced pressure, then adding ca. 3 ml of CH_3OH to the residue and filtering. Column chromatography (A-6 (NH_4^+)) of a portion of the insoluble material indicated that it was pure **9**. The sample was dried in vacuo over P_2O_5: mp 215-217°; uv (pH 0) 240 nm; mass spectrum *m/e* 182 (M), 167, 165, 151, 150, 139, 124 (M − NH_2CON), and 123 (M − NH_2CONH).

Anal. Calcd for $C_7H_{10}N_4O_2$: C, 46.15; H, 5.53. Found: C, 45.84; H, 5.40.

***N*-Phenylformamidoxime (22). (a) Synthesis.** Finely powdered aniline hydrochloride (520 mg, 4 mmol) and formamidoxime (240 mg, 4 mmol) were mixed and ground to a fine paste which was heated in an oil bath at 110° for 30 min. The resulting solid was dissolved in 3 ml of CH_3OH and 15 ml of $CHCl_3$ was added. The precipitated unreacted aniline HCl was collected and discarded. The solvents were removed from the filtrate, and the residue was chromatographed over a silica gel column, 12 × 200 mm, by elution with CH_3OH-$CHCl_3$ (1:1, v/v). The sample, after recrystallization from $CHCl_3$-*n*-heptane, migrated as a single component on a silica plate developed in $CHCl_3$-*n*-heptane (9:1): mp 113-117° (lit.[52] 138°); NMR (DMSO-d_6) δ 8.52 (d, 1 H, *NH*, $J_{NHCH} = 10$ Hz), 7.60 (d, 1 H, *CH*, $J_{CHNH} = 10$ Hz), 7.09 (m, 5 H, C_6H_5). Addition of D_2O caused the doublet at 8.52 to disappear and that at 7.60 to collapse to a singlet. Mass spectrum *m/e* (% intensity) 136 (100) M, 120 (42) M − O, 119 (28) M − OH, 93 (19), 92 (20), 91 (45), 77 (46).

(b) Irradiation. A sample of 50 mg of **22** dissolved in 15 ml of absolute EtOH was irradiated at 254 nm in the Rayonet reactor for 5 hr. The solvent was removed and the residue was applied to two 20 × 20 cm silica plates. When developed in $CHCl_3$-CH_3OH (9:1, v/v), the mixtures separated into five components, R_f's 0.33, 0.58, 0.71, 0.80, and 0.97. One product, that at R_f 0.33, appeared near the R_f of phenylurea, R_f 0.35, in this solvent, but the two components differed in uv absorption, NMR, and mass spectral properties. The chemical ionization mass spectrum of phenylurea manifested a single major peak at *m/e* 137 (M + 1), while the product eluted with R_f 0.33 produced a single major peak at 120 (M + 1).

Acknowledgment. The authors acknowledge the continued interest, support, and helpful discussions of Dr. George Bosworth Brown and thank Ms. Mary Ann Caolo for capable technical assistance, Mr. Marvin J. Olsen for assistance with NMR determinations, and Mr. Gerald Reiser for the p*K* determination. We thank Dr. Frank Field and collaborators of the Mass Spectrometry Center, Rockefeller University, for mass spectral determinations. Their work is supported in part by Grant No. RR-862-01 from the Biotechnology Facilities and Resources, N.I.H.

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(1) This investigation was supported in part by funds from the Public Health Service Research Grant No. CA 08748 and CA 15274 from the National Cancer Institute and from the Atomic Energy Commission (AT(11-1)-3521).
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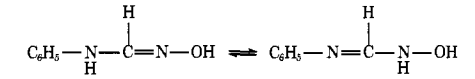

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