The Chemistry of Nitrilium Salts. Part 4.[1] Some Reactions of 5-Amino-4-(*C*-cyanoformimidoyl)imidazoles Obtained from Nitrilium Trifluoromethanesulphonate Salts and Diaminomaleonitrile

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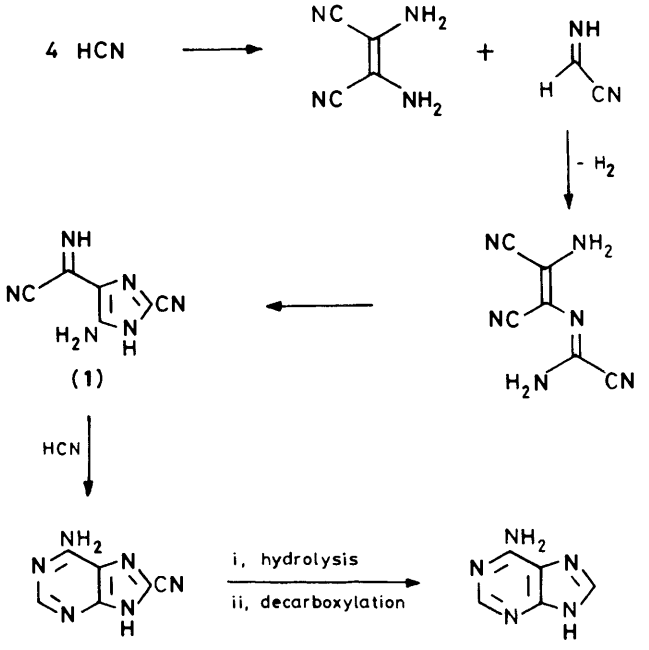
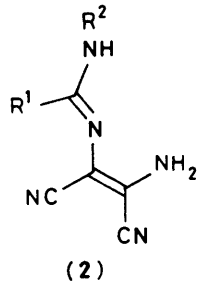
Diaminomaleonitrile (DAMN) has been found to react readily with the nitrilium trifluoromethanesulphonate (triflate) salts $[R^1C{\equiv}NMe]^+\ \bar{O}Tf$ (R^1 = Ph or Me) to give the amidinium salts $[MeH\bar{N}\bar{C}\bar{R}^1\bar{N}\bar{H}C(CN){=}C(CN)NH_2]^+\ \bar{O}Tf$, which, after base treatment under different conditions, afford 5-amino-4-carbamoylimidazoles, 5-amino-4-cyanoimidazoles, or 5-amino-4-(*C*-cyanoformimidoyl)-imidazoles. The amidinium salts react with aldehydes and ketones at room temperature to give 6-carbamoyl-1,2-dihydropurinium salts; this reaction is accelerated in the presence of a small amount of pyridine. Similarly, 5-amino-4-(*C*-cyanoformimidoyl)-1,2-dimethylimidazole reacts with aldehydes, ketones, 1,2- and 1,3-diketones, and keto esters to give 6-carbamoyl-1,2-dihydropurines, which, in some cases are readily oxidised in air to the corresponding 6-carbamoylpurines.

Diaminomaleonitrile, a tetramer of hydrogen cyanide, has been implicated as a key reagent in the prebiotic synthesis of purines.[2] It has been proposed recently by Schwartz[3] that one possible pathway to adenine from hydrogen cyanide involves the intermediate formation of 5-amino-4-(*C*-cyanoformimidoyl)-1*H*-imidazole-2-carbonitrile (**1**)] (Scheme 1). For



Scheme 1.

some time we have been interested in the chemistry of nitrilium salts[1,4] and it seemed possible that these highly electrophilic species may react with the weak nucleophile DAMN to form amidines of type (**2**), and these, in turn, could be useful synthons for a variety of heterocyclic compounds, and, in particular, purine derivatives *via* cyanoformimidoylimidazoles of type (**1**). Consequently, we have carried out a detailed study of the reactions of some nitrilium triflate salts with DAMN and the results of this investigation are now reported. Part of this work has appeared in a preliminary communication.[5]

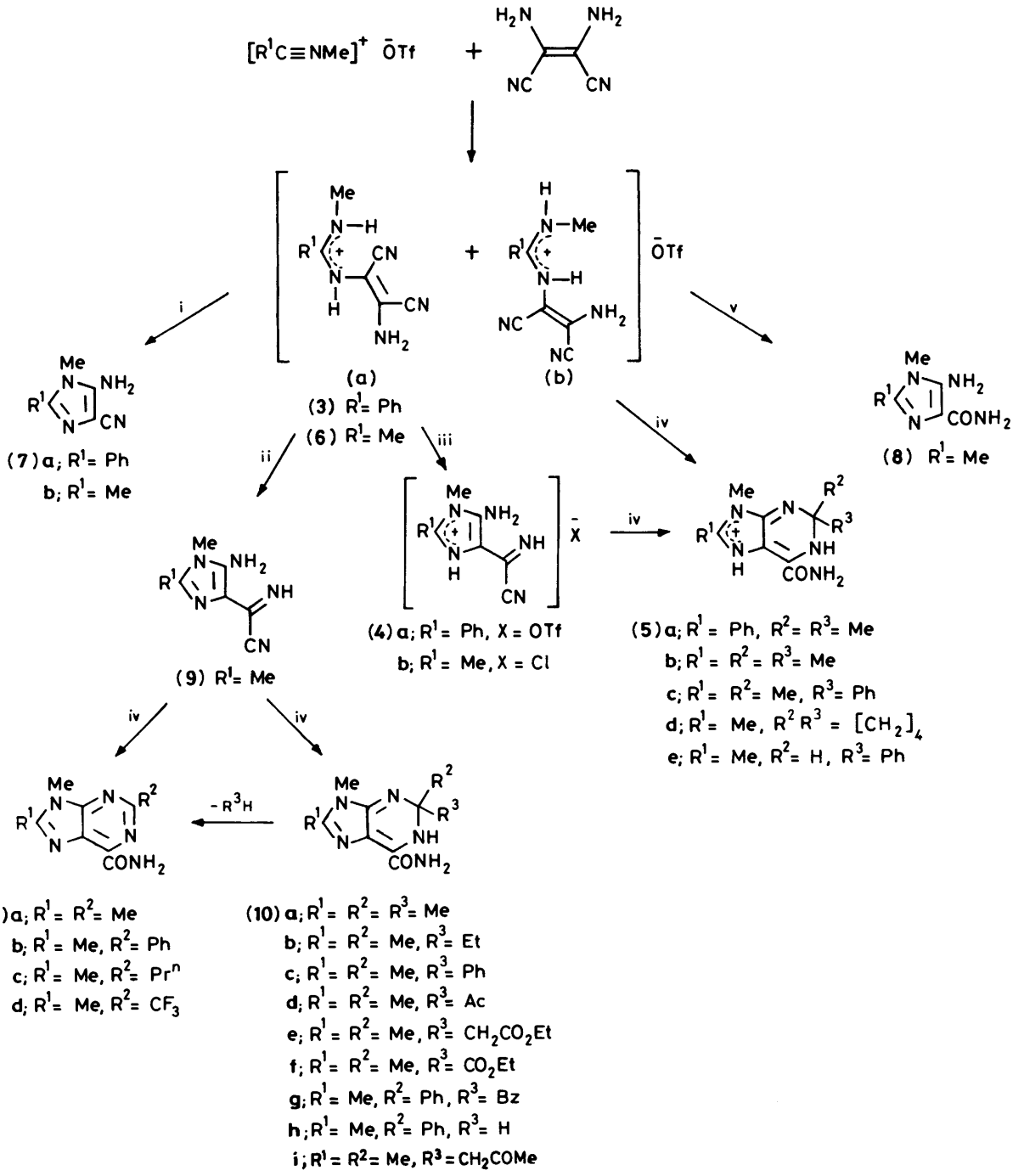


(**2**)

Results and Discussion

When equimolar amounts of DAMN and *N*-methylbenzonitrilium triflate were mixed in dry nitromethane at room temperature white needle crystals of the amidinium salt (**3**) (Scheme 2) separated almost immediately. Attempts to recrystallise the salt by heating in a mixture of chloroform and nitromethane gave a lemon-yellow crystalline isomer, which had an identical m.p. with that of compound (**3**), but only a weak $\nu(C{\equiv}N)$ absorption at 2 235 cm^{-1} and a $\nu(\bar{N}{-}\bar{C}{=}\bar{N})$ absorption at 1 660 cm^{-1} [*cf.* $\nu(C{\equiv}N)$ 2 225 s cm^{-1} and $\nu(\bar{N}{-}\bar{C}{=}\bar{N})$ 1 665 cm^{-1} for compound (**3**)] in the i.r. spectrum. In addition, the ^1H n.m.r. spectrum of the yellow compound shows only a single band at δ 3.70 for the NMe group, while that of compound (**3**) shows two singlets, at δ 3.70 and 3.68 in a 1.5:1 ratio corresponding to the *cis*-(**3a**) and *trans*-(**3b**) isomer respectively.[6] On this basis the yellow isomer is tentatively assigned the structure (**4a**). Hydrolysis of either compound (**3**) or (**4a**) with aqueous sodium carbonate gave only a dark tar, but both compounds reacted rapidly with acetone to give high yields of the same yellow solid, believed to be the 1,2-dihydropurinium salt (**5a**) from elemental analysis and spectroscopic data. When the amidinium salt (**3**) was heated under reflux with 2M-aqueous KOH the only product isolated was 5-amino-1-methyl-2-phenyl-1*H*-imidazole-4-carbonitrile (**7a**) in 50% yield.

Reaction between *N*-methylacetonitrilium triflate and DAMN in dry nitromethane at room temperature gave the amidinium salt (**6**) as a 1.4:1 mixture of *cis*- and *trans*-isomer. Unlike the *C*-phenyl analogue (**3**) this compound does not isomerise to an imidazolinium triflate on mild heating. Basification of compound (**6**) with aqueous NaOH at room



Scheme 2. *Reagents and conditions:* i, NaOH, room temp.; ii, Na_2CO_3; iii, heat; iv, R^2R^3CO; v, NaOH, heat

temperature gave the 5-amino-4-cyanoimidazole derivative (**7b**) in 32% yield. When the salt (**6**) was boiled in aqueous NaOH for 30 min, the corresponding 5-aminoimidazole-4-carboxamide (**8**) was obtained in 26% yield. No attempt has been made to optimise the yields of compounds (**7b**) and (**8**), and their low recovery probably reflects their poor solubilities in the common organic solvents used for extraction. Controlled basification of the salt (**6**) to pH 8—9 with 1M-sodium carbonate gave an 80% yield of the 5-amino-4-(cyanoformimidoyl)imidazole (**9**) as a pale yellow crystalline solid. The i.r. spectrum of this product showed typical N–H stretching vibrations at 3 352m, 3 255s, 3 205m, and 3 100m, but no absorption in the ν(C≡N) region. However, the hydrochloride salt of compound (**9**), *i.e.* compound (**4b**), did show a weak band at 2 245 cm^{-1}, similar to that exhibited by the analogous triflate salt (**4a**). In the solid state, compound (**9**) can be stored without decomposition for months in a well stoppered vessel. In solution in chloroform, methanol, ethanol, or acetonitrile even under nitrogen the pale yellow colour changes rapidly to green and then brown and decomposition is complete within a few hours.

The *N*-methylamidinium salt (**6**) reacts with acetone in the presence of 5 mol% of pyridine at room temperature during 2 h to give yellow crystals of the 6-carbamoyl-1,2-dihydropurinium triflate salt (**5b**) in 80% yield; in the absence of pyridine the same product was obtained in similar yield but only after several days at room temperature. Using a pyridine catalyst, reactions with acetophenone, cyclohexanone, and benzaldehyde gave the salts (**5c—e**) in 50—70% yield (Scheme 2). Addition of an excess of

acetone to compound (**9**) at room temperature resulted in a rapid, exothermic reaction with precipitation of the 6-carbamoyl-1,2-dihydropurine (**10a**) as orange-red crystals; the structure of this compound has been fully confirmed by a single-crystal *X*-ray structure analysis.[7] Similar reactions occur with butan-2-one, acetophenone, butane-2,3-dione, ethyl acetoacetate, ethyl pyruvate, benzil, and benzaldehyde to give the compounds (**10b—h**) in good yields as yellow-orange solids. The 6-carbamoyl-1,2-dihydropurine derivatives have been fully characterised by i.r. and ^{1}H n.m.r. spectroscopy, and mass spectrometry. The u.v. spectra of these compounds in ethanol show a maximum in the range λ 423—438 nm ($\varepsilon_{max.}$ 3 600—5 900). It seems probable that even in ethanol the monomeric compounds are in equilibrium with the hydrogen-bonded dimer (Figure). Support for this comes from the observation of an isobestic point as λ 404 nm in the u.v. spectrum of compound (**10a**) in ethanol as the concentration is varied between 10^{-2} and 10^{-4} M.

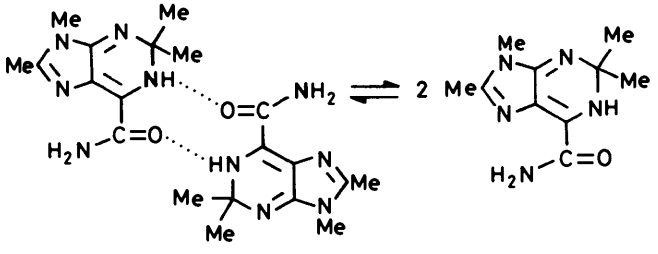
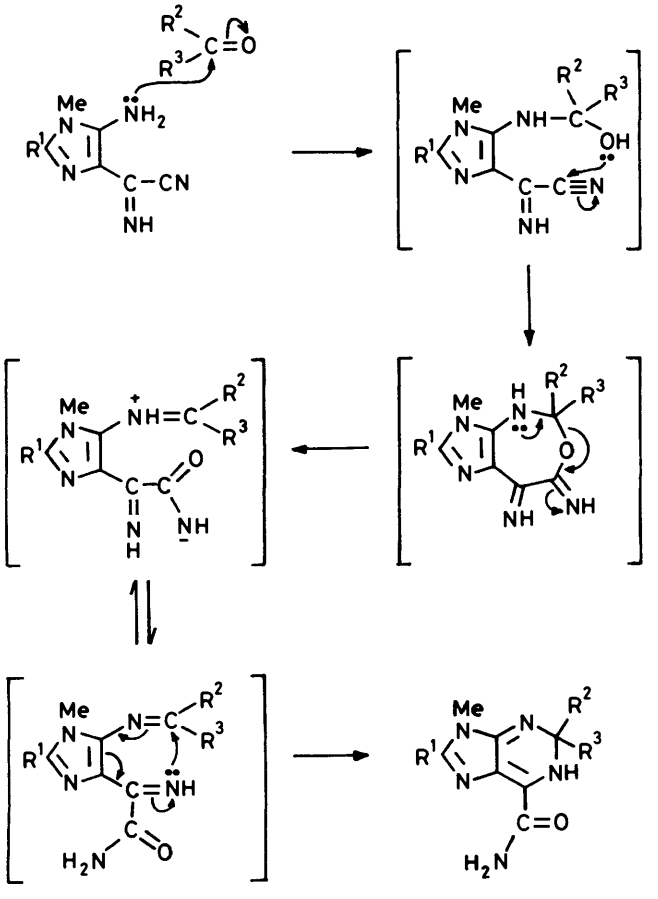


Figure.

In chloroform the compound appears to be present mainly as the dimer as a change in concentration from 0.11 to 1.4 × 10^{-2}M causes no shift in the N–H stretching vibrations in the i.r. spectrum. The compounds (**10a—c** and **h**) can be stored unchanged in air for months, but the other derivatives are slowly oxidised to 6-carbamoyl-2-methylpurine [from (**10d—f**)] or 6-carbamoyl-2-phenylpurine [from (**10g**)]. Similarly, compounds (**10a—c**) can be recovered from solutions in chloroform or ethanol after several weeks, but solutions of compounds (**10d—g**) in these solvents are slowly converted into the 2-methyl- or 2-phenyl-6-carbamoylpurines which precipitate from solution. In the reactions between pentane-2,4-dione, butanal, and 1,1,1,-trifluoropentane-2,4-dione and compound (**9**) the intermediate dihydropurine derivatives were not isolated, but, instead, the solutions were kept at room temperature for 2—4 days to give the corresponding purines (**11a**, **c**, and **d**) respectively (see Scheme 2). The reaction of compound (**9**) with pentane-2,4-dione in chloroform was monitored by g.l.c. (1.5 Poropak Q column at 175 °C) for 77 h and the loss of 1 mol of acetone per mol of 6-carbamoyl-2,8,9-trimethylpurine (**11a**) produced from the dihydropurine intermediate (**10i**) could be followed easily. To our knowledge these reactions represent the first syntheses of 1,2-dihydropurine and 1,2-dihydropurinium salts of this type, and a possible mechanism for their formation from compound (**9**) is outlined in Scheme 3.



Scheme 3.

Experimental

I.r. spectra were recorded on Perkin-Elmer 197 or 397 instruments. ^{1}H N.m.r. spectra were recorded on a Perkin-Elmer R12 (60 MHz) or R32 (90 MHz) spectrometer with Me_4Si as internal standard. ^{13}C N.m.r. spectra were recorded on a Bruker WP 80 instrument at 20.1 MHz. Mass spectra were obtained using either an A.E.I. MS902 or a Kratos MS45 mass spectrometer, and u.v. spectra were recorded on a Cary 118 instrument.

N-Methyl-aceto- and -benzo-nitrilium triflate salts were prepared as described previously,[2] and all solvents and reagents were purified and dried by recognised procedures.[8]

Reactions of Diaminomaleonitrile with Nitrilium Triflate Salts.—(a) N-*Methylbenzonitrilium triflate.* Solid DAMN (1.31 g, 12.13 mmol) was added to a solution of the nitrilium salt (3.24 g, 12.13 mmol) in dry nitromethane (10 cm^3) inside a dry box. An exothermic reaction occurred with slow precipitation of a solid. After 12 h at room temperature the precipitate was filtered off and washed with small portions of nitromethane and chloroform to give white needles of N-[(*Z*)-2-*amino*-1,2-*dicyanovinyl*]-N′-*methylbenzamidinium triflate*, m.p. 184—185 °C (decomp.) (3.4 g, 80%) as a mixture of *cis*-(**3a**) and *trans*-(**3b**) isomers (Found: C, 41.7; H, 3.3; N, 18.7; $C_{13}H_{12}F_3N_5O_3S$ requires C, 41.6; H, 3.2; N, 18.7; S, 8.54%); $\nu_{max.}$(Nujol) 3 330s (N–H), 3 200vs (N–H), 3 100s (N–H), 2 225s (C≡N), 1 665vs (N–C–N) 1 642s, 1 605 (δ N–H), 1 580m (C=C), 1 300—1 210vs br (OTf), 1 160s sh (OTf), and 1 030vs cm^{-1} (OTf); *m/z* 225 (*M* − TfOH, 5.4%); δ_H (90 MHz; [$^2H_6$] acetone) (**3a**) 3.70 (s, NMe); (**3b**) 3.68 (s, NMe) and 7.57—8.0 (m, Ph).

(b) N-*Methylacetonitrilium triflate.* Reaction between solid DAMN (5.94 g, 55 mmol) and the nitrilium salt (11.3 g, 55 mmol) in dry nitromethane (15 cm^3) gave a deep orange, homogeneous solution after 20 h at room temperature. Removal of the solvent under reduced pressure gave a hard, orange gum (15.67 g, 91%), which on being washed with a small quantity of ethyl acetate gave white needles of N-[(*Z*)-2-amino-1,2-dicyanovinyl]-*N*′-vinylacetamidinium triflate (9.4 g, 60%) as a 1.4:1 mixture of *cis*-(**6a**) and *trans*-(**6b**) isomers; $\nu_{max.}$($CHCl_3$) 2 210w (C≡N), 2 180s (C≡N), 1 665s (N–C–N), 1 640s, 1 600s (δ N–H), 1 570m (C=C), 1 300—1 200 br (OTf), 1 160s (OTf), and 1 030s cm^{-1} (OTf); δ_H (90 MHz; [$^2H_6$]acetone) (**6a**) 2.54 (s, CMe) and 3.23 (s, NMe); (**6b**) 2.43 (s, CMe), 3.18 (s, NMe), 7.67 (br, NH_2), 9.02 (br, NH), and 9.82 (br, NH).

Preparation of 5-Amino-4-(c-cyanoformimidoyl)-1-methyl-2-phenylimidazolium Triflate (**4a**).—A solution of compound (**3**) (1.35 g, 3.60 mmol) in a mixture of nitromethane (5 cm^3) and chloroform (15—20 cm^3) was heated under reflux for 30 min. On cooling, yellow needles of the *title compound* (**4a**) m.p. 184—185 °C (1.31 g, 97%) separated out and were filtered off and washed with chloroform (Found: C, 41.9; H, 3.2; N, 19.0; S, 8.3. $C_{13}H_{12}F_3N_5O_3S$ requires C, 41.6; H, 3.2; N, 18.7; S, 8.54%); $\nu_{max.}$(Nujol) 3 450m (NH), 3 320m br (NH), 3 280m br (NH), 3 245m br (NH), 3 150s br (NH), 2 235w (C≡N), 1 660s (N–C–N), 1 635s, 1 610s, (δ N–H) 1 595s (ring C=C), 1 300—1 200vs br (OTf), 1 160s (OTf), and 1 030s cm^{-1} (OTf); *m/z* 225 (*M* − TfOH, 49.6%); δ_H (90 MHz; [$^2H_6$]acetone) 3.70 (s, 3 H, NMe), 7.57—8.0 (m, 5 H, Ph), 8.2 (br, 2 H, NH_2), and 8.5—9.5 (vbr, 1 H, NH).

Preparation of 5-Amino-1-methyl-2-phenyl-1H-imidazole-4-carbonitrile (**7a**).—An aqueous solution of KOH (2M) was added dropwise to a solution of compound (**3**) (1.50 g, 4.03 mmol) in ethanol (15 cm^3) until a pH of 10—11 was reached. The solution was heated under reflux for 30 min and, after having cooled, extraction with chloroform (3 × 20 cm^3) gave, after work-up, compound (**7a**) (0.42 g, 50%) as white crystals, m.p. 192 °C, identified by comparison with an authentic sample.

The same product was also obtained in similar yield by basification of an aqueous methanolic solution of compound (**4a**) to pH 11 with aqueous sodium carbonate (2M) followed by heating on a water-bath for 30 min.

Preparation of 5-Amino-1,2-dimethyl-1H-imidazole-4-carbonitrile (**7b**).—To an aqueous methanolic solution (60 cm^3; 1:2 v/v) of compound (**9**) (1.35 g, 8.28 mmol) (see below) was added dropwise aqueous 2M-NaOH until pH 11 was reached. Extraction with chloroform (30 × 20 cm^3) gave, after work-up, compound (**7b**) (0.36 g, 32%) as a pale yellow solid, m.p. 230—235 °C (decomp.) (Found: C, 52.5; H, 5.9; N, 40.8. $C_8H_8N_4$ requires C, 52.9; H, 5.9; N, 41.15%); $\nu_{max.}$(Nujol) 3 355s (NH), 3 320s (NH), 3 120s (NH), 2 200vs (C≡N), 1 665s (C=N), 1 595 (δ NH), and 1 555m cm^{-1} (N=C–N); $\lambda_{max.}$(EtOH) 305infl (ε 44 dm^3 mol^{-1} cm^{-1}) and 247 nm (13 350); *m/z* 135 (*M* − H, 48.1%).

Preparation of 5-Amino-1,2-dimethyl-1H-imidazole-4-carboxamide (**8**).—Aqueous 2M-NaOH was added dropwise to a solution of compound (**6**) (1.11 g, 3.54 mmol) in ethanol (10 cm^3) until pH 10—11 was reached. The resulting deep orange solution was warmed on a water-bath for 30 min and, after having cooled, extraction with chloroform (7 × 10 cm^3) gave, after work-up, the *amide* (**8**) (0.14 g, 26%) as a yellow solid, m.p. 250—251 °C (decomp.), which was recrystallised from methanol (Found: C, 46.6; H, 6.2; N, 36.3. $C_6H_{10}N_4O$ requires C, 46.7; H, 6.5; N, 36.3%); $\nu_{max.}$(Nujol) 3 405s (NH), 3 330s (NH), 3 110s (NH), 1 665s (C=O), 1 620s, 1 610s (δ NH), and 1 560s cm^{-1} (N=C–N); *m/z* 154 (M^+, 62.8%); δ_H (90 MHz; [$^2H_6$]acetone) 2.19 (s, CMe) and 3.42 (s, NMe).

Preparation of 5-Amino-4-(C-cyanoformimidoyl)-1,2-dimethylimidazole (**9**).—Aqueous 2M-sodium carbonate was added dropwise to an aqueous solution of compound (**6**) (5.31 g, 16.95 mmol) until the pH was 8—9. Extraction with chloroform (40 × 20 cm^3) gave, after work-up, light yellow needles of the *title compound* (**9**), (2.30 g, 83%) m.p. 140—141 °C (decomp.) (Found: C, 51.5; H, 5.6; N, 42.6. $C_7H_9N_5$ requires C, 51.8; H, 5.5; N, 42.9%); $\nu_{max.}$(Nujol) 3 352m (NH), 3 255s (NH), 3 205m (NH), 3 100m (NH), 1 635m (C=N), 1 585s (δ NH) and 1 560s cm^{-1} (N=C–N); $\lambda_{max.}$(EtOH) 357 (9 350) and 223.5 nm (12 250); *m/z* 163 (M^+, 65.1%); δ_H (90 MHz; $CDCl_3$) 2.35 (s, CMe) and 3.36 (s, NMe).

Preparation of 6-Carbamoyl-1,2-dihydropurinium Triflate Salts (**5**).—*General synthetic procedure.* The *N*-methyl amidinium triflate salts (**3**) or (**6**) were dissolved in the dry aldehyde or ketone (R^2R^3CO, Scheme 2) and the mixture was left at room temperature for *ca.* 20 h. Reaction was accelerated by addition of pyridine (0.25 cm^3; 5 mol%) and by this means a high yield of product could be obtained after only 2 h at room temperature. In each case the product was isolated by addition of diethyl ether and cooling to 0 °C.

(a) *6-Carbamoyl-1,2-Dihydro-2,2,9-trimethyl-8-phenylpurinium triflate* (**5a**). A mixture of compound (**3**) (0.50 g, 1.33 mmol) and acetone (4 cm^3) after 3 days gave *compound* (**5a**) (0.56 g, 97%) as an orange solid, m.p. 195—196 °C (decomp.) (Found: C, 44.5; H, 4.5; N, 16.1; S. 7.3. $C_{16}H_{18}F_3N_5O_4S$ requires C, 44.34; H, 4.2; N, 16.16; S, 7.4%); $\nu_{max.}$(Nujol) 3 330m (NH), 3 205vs (NH), 3 175vs (NH), 1 700s, 1 658s sh ($CONH_2$) 1 650vs, 1 630w, 1 615s, 1 595s, 1 300—1 225vs br (OTf), 1 160s (OTf), and 1 030vs cm^{-1} (OTf); δ_H (90 MHz; [$^2H_6$]acetone) 1.93 (s, CMe_2), 3.73 (s, NMe), and 7.54—8.0 (m, Ph); *m/z* 283 (*M* − TfOH, 4.8%).

The same product was also obtained in 85% yield (0.33 g) by dissolving compound (**4a**) (0.34 g, 0.9 mmol) in dry acetone (2 cm^3) and leaving the solution at room temperature for 18 days.

(b) *6-Carbamoyl-1,2-dihydro-2,2,8,9-tetramethylpurinium triflate* (**5b**). Addition of pyridine (0.25 cm^3; 5 mol%) to a solution of compound (**6**) (1.0 g, 32 mmol) in acetone (5 cm^3) caused it to turn yellow and darken rapidly. After 2 h yellow crystals of *compound* (**5b**) (0.95 g, 80%), m.p. 180 °C (decomp.), precipitated out (Found: C, 35.6; H, 4.2; N, 19.2; F, 14.9. $C_{11}H_{16}F_3N_5O_4S$ requires C, 35.6; H, 4.3; N, 18.9; F, 15.4%); δ_H [90 MHz; $(CD_3)_2SO$] 1.65 (s, 2 × Me), 2.36 (s, CMe), 3.45 (s, NMe), 8.45 (br s, NH), 8.71 (br s, NH), and 9.5 (br s, NH); $\nu_{max.}$(Nujol) 3 375m (NH), 3 345s (NH), 3 240br (NH), 1 705s, 1 665s ($CONH_2$), 1 540s, 1 300—1 200s br (OTf), 1 160s (OTf), and 1 030s cm^{-1} (OTf); *m/z* 221 (*M* − TfOH, 14.2%).

(c) *6-Carbamoyl-1,2-dihydro-2,8,9-trimethyl-2-phenylpurinium triflate* (**5c**). Reaction between compound (**6**) (1.0 g, 32 mmol) and acetophenone (5 cm^3) in the presence of pyridine (0.25 cm^3) gave, after 2 h at room temperature, the *salt* (**5c**) (0.93 g, 69%) as a yellow solid (Found: C, 44.6; H, 4.0; N, 16.3; F, 13.1. $C_{16}H_{18}F_3N_5O_4S$ requires C, 44.4; H, 4.16; N, 16.2; F, 13.1%); $\nu_{max.}$(Nujol) 3 400s (NH), 3 280s (NH), 3 200s (NH), 1 707s, 1 660s ($CONH_2$), 1 608s, 1 260s (OTf), 1 180s (OTf), and 1 040s cm^{-1} (OTf).

(d) *6-Carbamoyl-1,2-dihydro-8,9-dimethyl-2,2-tetramethylenepurinium triflate* (**5d**).* Under similar conditions reaction between compound (**6**) (1.0 g, 32 mmol) and an excess of cyclohexanone gave yellow crystals of the *salt* (**5d**) (0.63 g, 50%), m.p. 162 °C (decomp.) (Found: C, 40.9; H, 4.8; N, 17.3. $C_{14}H_{20}F_3N_5O_4S$ requires C, 40.9; H, 4.9; N, 17.0%); $\nu_{max.}$(Nujol) 3 401s (NH), 3 300s br (NH), 1 688w, 1 643m ($CONH_2$), 1 600m, 1 260s (OTf), 1 180s, (OTf), and 1 040s cm^{-1} (OTf); *m/z* 224 (*M* − TfOH − NH_3, 33.8%).

(e) *6-Carbamoyl-1,2-dihydro-8,9-dimethyl-2-phenylpurinium triflate* (**5e**). Reaction between compound (**6**) (1.0 g, 32 mmol) and benzaldehyde (5 cm^3) in the presence of pyridine (5 mol%) gave, after 2 h at room temperature, *compound* (**5e**) (0.77 g, 60%) as a yellow solid, m.p. 178 °C (decomp.) (Found: C, 43.0; H, 3.9. $C_{15}H_{16}F_3N_5O_4S$ requires C, 43.0; H, 3.9%); $\nu_{max.}$ 3 850w (NH), 3 280w (NH), 1 700m, 1 665m ($CONH_2$), 1 605m, 1 590m, 1 240s (OTf), 1 180s (OTf), and 1 060s cm^{-1} (OTf); *m/z* 269 (*M* − TfOH, 6.6%).

Reactions of 5-Amino-4-(c-cyanoformimidoyl)-1,2-dimethylimidazole (**9**) *with Aldehydes and Ketones.*—(a) *Acetone.* A

* 6-Carbamoyl-8,9-dimethyl-1,2-dihydropurinium-2-spirocyclopentane triflate.

solution of compound (**9**) (0.90 g, 5.25 mmol) in acetone (50 cm^3) was kept for 20 h at room temperature during which time it deposited bright red needles of *compound* (**10a**) (1.10 g, 90%), m.p. 190—192 °C (decomp.) (Found: C, 54.3; H, 7.0; N, 31.4. $C_{10}H_{15}N_5O$ requires C, 54.3; H, 6.8; N, 31.6%); $\nu_{max.}$(Nujol) 3 315sh (NH), 3 290vs (NH), 3 250sh (NH), 3 155m (NH), 1 675sh, 1 660vs ($CONH_2$), 1 620s, 1 608vs, and 1 595sh cm^{-1}; δ_H (90 MHz; $CDCl_3$) 1.46 (s, 6 H, CMe_2), 2.19 (s, 3 H, CMe), 3.19 (s, 3 H, NMe), 4.6—3.9 (v br, 1 H, NH), 5.19 (br, 1 H, NH), and 8.51 (br, 1 H, NH); δ_C[$(CD_3)_2SO$] 13.79 (q, CMe_2), 27.27 (q, C*Me*), 29.08 (q, NMe), 71.72 (s, C-2), 117.6 (s, C-5), 131.9 (s, C-6), 153.9 (s, C-4), 156.0 (s, C-8), and 163.2 (s, C=O); $\lambda_{max.}$(EtOH) 432.5 (5 900), 275infl (2 550), and 218 nm (14 700).

(b) *Butan-2-one.* Reaction between compound (**9**) (0.14 g, 0.86 mmol) and butan-2-one (6 cm^3) for 2 days at room temperature gave red crystals of *compound* (**10b**) (0.13 g, 65%), m.p. 190—192 °C (decomp.) (Found: C, 56.4; H, 7.3; N, 29.8. $C_{11}H_{17}N_5O$ requires C, 56.15; H, 7.3; N, 29.8%); $\nu_{max.}$ 3 365sh (NH), 3 340vs (NH), 3 265sh (NH), 3 190m (NH), 1 672vs, 1 655s ($CONH_2$) 1 625sh, 1 615s, and 1 595s cm^{-1}; δ_H (90 MHz; $CDCl_3$) 0.9 (t, *J* 7 Hz, 3 H, CH_2Me), 1.37 (s, 3 H, CMe), 1.7 (q, 2 H, CH_2Me), 2.18 (s, 3 H, CMe), 3.17 (s, 3 H, NMe), 3.83—4.23 (v br, 1 H, NH), 6.11 (br, 1 H, NH), and 8.45 (br, 1 H, NH); *m/z* 235 (M^+, 14.0%); $\lambda_{max.}$(EtOH) 438 (5 250), 280infl (2 600), and 218 nm (14 800).

(c) *Acetophenone.* Reaction between compound (**9**) (0.24 g, 14.72 mmol) and acetophenone (10 cm^3) at room temperature for 1 week gave pale orange crystals of *compound* (**10c**) (0.34 g, 82%), which were recrystallised from a mixture of chloroform–diethyl ether; m.p. 155—157 °C (decomp.) (Found: C, 63.5; H, 6.0; N, 24.4. $C_{15}H_{17}N_5O$ requires C, 63.6; H, 6.05; N, 24.7%); $\nu_{max.}$(Nujol) 3 400w (NH), 3 350w (NH), 3 300s (NH), 3 190m (NH), 1 690m, 1 680m, 1 660s ($CONH_2$), 1 650s, and 1 598m cm^{-1}; δ_H (90 MHz; $CDCl_3$) 1.86 (s, 3 H, CMe), 2.21 (s, 3 H, CMe), 3.30 (s, 3 H, NMe), 3.6—4.1 (v br, 1 H, NH), 5.9 (br, 1 H, NH), 7.2—7.7 (m, 5 H, Ph), and 8.48 (br, 1 H, NH); *m/z* 283 (M^+, 13.7%); $\lambda_{max.}$(EtOH) 426 (4 600) and 290infl nm (2 150).

(d) *Butane-2,3-dione* Addition of butane-2,3-dione (0.077 g, 0.9 mmol) to a suspension of compound (**9**) (0.1 g, 0.6 mmol) in ethanol (4 cm^3) gave, after work-up, compound (**10d**) (0.1 g, 67%) as an orange solid, m.p. 157—158 °C (decomp.) (Found: C, 52.7; H, 5.9; N, 28.0. $C_{11}H_{15}N_5O_2$ requires C, 53.0; H, 6.1; N, 28.1%); $\nu_{max.}$(Nujol) 3 355s (NH), 3 330sh (NH), 3 255m (NH), 3 155m (NH), 1 712s (C=O), 1 695s, 1 655s ($CONH_2$), 1 620m, and 1 595s cm^{-1}; δ_H (90 MHz; $CDCl_3$) 1.45 (s, 3 H, CMe), 2.22 (s, 3 H, CMe), 2.29 (s, 3 H, CMe), 3.23 (s, 3 H, NMe), 6.06 (br, 1 H, NH), and 8.40 (br, 1 H, NH)—the other NH band was not seen; *m/z* 249 (M^+, 0.9%).

(e) *Ethyl acetoacetate.* Under similar conditions ethyl acetoacetate (0.78 g, 0.6 mmol) and compound (**9**) (0.1 g, 0.6 mmol) in ethanol (4 cm^3) gave orange needles of the *ester* (**10e**) (0.14 g, 80%), m.p. 250—251 °C (decomp.) (Found: C, 53.3; H, 66.7; N, 24.0. $C_{13}H_{19}N_5O_3$ requires C, 53.2; H, 6.5; N, 23.9%); $\nu_{max.}$(Nujol) 3 385m (NH), 3 350m (NH), 3 100m (NH), 1 725s (C=O), 1 680s ($CONH_2$), and 1 620s cm^{-1}; δ_H (90 MHz; $CDCl_3$) 1.21 (t, *J* 7 Hz, 3 H, CH_2Me), 1.57 (s, 3 H, CMe), 2.18 (s, 3 H, CMe), 2.60 (d, J_{ab} 14 Hz, 1 H, CH_aCO), 2.91 (d, 1 H, CH_bCO), 3.16 (s, 3 H, NMe), 4.10 (q, 2 H, OCH_2), 6.14 (br, 1 H, NH), and 8.41 (br, 1 H, NH)—the other NH band was not seen; *m/z* 293 (M^+, 2.8%); $\lambda_{max.}$(EtOH) 432.5 (5 500) 278infl (2 950), and 217 nm (15 350).

(f) *Ethyl pyruvate.* When ethyl pyruvate (0.07 g, 0.6 mmol) was added to compound (**9**) (0.1 g, 0.6 mmol) in ethanol (4 cm^3) the reaction was slightly exothermic, and the *ester* (**10f**) precipitated out as a fine yellow solid (0.09 g, 54%), m.p. 174—175 °C (decomp.) (Found: C, 51.7; H, 6.3; N, 25.2. $C_{12}H_{17}N_5O_3$ requires C, 51.6; H, 6.1; N, 25.1%); $\nu_{max.}$(Nujol) 3 345s (NH), 3 325s (NH), 1 720m (C=O), 1 695m, 1 665s ($CONH_2$), 1 620m, and 1 605m cm^{-1}; δ_H (90 MHz; $CDCl_3$) 1.30 (t, *J* 7.5 Hz, 3 H, CH_2Me), 1.76 (s, 3 H, CMe), 2.27 (s, 3 H, CMe), 3.36 (s, 3 H, NMe), 4.24 (q, 2 H, OCH_2), 6.11 (br, 1 H, NH), and 8.55 (br, 1 H, NH)—the other NH band could not be detected; *m/z* 279 (M^+, 0.7%); $\lambda_{max.}$(EtOH) 423 (5 500), 283infl (2 700), and 217.5 nm (14 400).

(g) *Benzil.* Benzil (0.126 g, 0.6 mmol) and compound (**9**) (0.10 g, 0.6 mmol) in ethanol (5 cm^3) gave yellow needles of *compound* (**10g**) (0.21 g, 93%), m.p. 188—190 °C (decomp.) (Found: C, 67.6; H, 5.1; N, 19.0. $C_{21}H_{19}N_5O_2$ requires C, 67.55; H, 5.1; N, 18.75%); $\nu_{max.}$(Nujol) 3 390s (NH), 3 315s (NH), 3 150m (NH), 1 685s (C=O), 1 670s ($CONH_2$), 1 620w, and 1 595s cm^{-1}; δ_H (90 MHz; $CDCl_3$) 2.28 (s, 3 H, CMe), 3.34 (s, 3 H, NMe), 7.7—7.24 (m, 10 H, Ph and COPh), 6.20 (br, 1 H, NH), and 8.49 (s, 1 H, NH)—the other NH band was not seen; *m/z* 373 (M^+, 6.6%); $\lambda_{max.}$(EtOH) 435 (3 650), 290infl (5 850), and 247.5 nm (21 500).

(h) *Benzaldehyde.* A strongly exothermic reaction occurred when benzaldehyde (4 cm^3) was added to compound (**9**) (0.5 g, 3.07 mmol) to give the product (**10h**) (0.80 g, 97%), as a yellow solid, which was recrystallised from a mixture of chloroform–diethyl ether, m.p. 240—244 °C (decomp.) (Found: C, 62.3; H, 5.3; N, 26.1. $C_{14}H_{13}N_5O$ requires C, 62.4; H, 5.6; N, 26.0%); $\nu_{max.}$ 3 330m (NH), 3 280s (NH), 3 180w (NH), 1 680s, 1 658s ($CONH_2$), 1 620sh, and 1 600s cm^{-1}; δ_H (90 MHz; $CDCl_3$) 2.27 (s, 3 H, CMe), 3.29 (s, 3 H, NMe), 6.14 (s, 1 H, C*H*Ph), 7.3—7.7 (m, 5 H, Ph), 6.00 (br, 1 H, NH), and 8.59 (br 1 H, NH)—the other NH band could not be detected; *m/z* 269 (M^+, 17.7%); $\lambda_{max.}$(EtOH) 429.5 (4 000), 303infl (3 400), 284infl (4 950), and 242infl nm (11 100).

Preparation of 6-*Carbamoylpurines* (**11**).—(a) *From pentane-2,4-dione.* Pentane-2,4-dione (0.09 g, 0.9 mmol) was added to a suspension of compound (**9**) (0.1 g, 0.6 mmol) in ethanol (4 cm^3) and the mixture was left at room temperature for 4 days to give a white solid precipitate of compound (**11a**) (0.08 g, 65%), which was recrystallised from hot ethanol, m.p. 270—272 °C (decomp.), (Found: C, 52.4; H, 5.2; N, 34.4. $C_9H_{11}N_5O$ requires C, 52.7; H, 5.4; N, 34.1%); $\nu_{max.}$ 3 350s (NH), 3 160m (NH), 1 690s ($CONH_2$), 1 635w, and 1 600s cm^{-1}; δ_H (90 MHz; $CDCl_3$) 2.66 (s, 3 H, CMe), 2.83 (s, 3 H, CMe), 3.77 (s, 3 H, NMe), 6.30 (br, 1 H, NH), and 8.52 (br, 1 H, NH); *m/z* 205 (M^+, 27.8%); $\lambda_{max.}$(EtOH) 295 (9 150), 254infl (2 970), and 244infl nm (2 950).

(b) *From compound* (**10d**). When a solution of the acetyl derivative (**10d**) (0.036 g, 0.15 mmol) in the minimum amount of chloroform was kept at room temperature for 6 h, crystals of compound (**11a**) (0.026 g, 87%) precipitated out.

(c) *From compound* (**10e**). A suspension of the ester (**10e**) (0.06 g, 0.2 mmol) in ethanol (5 cm^3) was refluxed for 30 min to give a homogeneous yellow solution. Removal of most of the solvent, followed by cooling in an ice-bath, gave compound (**11a**) (0.035 g, 85%).

(d) *From compound* (**10g**). A suspension of the benzoyl derivative (**10g**) (0.075 g, 0.2 mmol) in chloroform (3 cm^3) was warmed on a water-bath for 5 min and the resulting homogeneous solution was kept at room temperature for 1 week whereupon *compound* (**11b**) (0.05 g, 93%) slowly precipitated out as a white solid, which was recrystallised from hot methanol, m.p. 277 °C (decomp.), (Found: C, 62.7; H, 4.8; N, 26.3. $C_{14}H_{13}N_5O$ requires C, 62.9; H, 4.9; N, 26.2%); $\nu_{max.}$(Nujol) 3 300s (NH), 3 150m (NH), 1 693s ($CONH_2$), 1 640m, 1 605m, and 1 593s cm^{-1}; δ_H (90 MHz; $CDCl_3$) 2.76 (s, 3 H, CMe), 3.91 (s, 3 H, NMe), and 8.32—8.12 (m, 5 H, Ph)—the NH protons could not be seen; *m/z* 268 (M^+, 18%); $\lambda_{max.}$(EtOH) 316 (10 550), 274infl (13 300), and 251 nm (28 400).

(e) *From compound* (**10h**). A solution of compound (**10h**) (0.24 g, 0.89 mmol) in chloroform (20 cm^3) was refluxed for 4 h to give compound (**11b**) (0.14 g, 59%).

(f) *From butyraldehyde.* Freshly distilled butyraldehyde (0.5 cm^3) was added to compound (**9**) (0.1 g, 0.6 mmol), and a

strongly exothermic reaction ensued. Addition of diethyl ether (2 cm^3) caused precipitation of a small amount of a dark brown impurity which was removed by filtration. Addition of further ether (4 cm^3) gave the *propyl derivative* (**11c**) (0.13 g, 93%) which was recrystallised from methanol as white needles, m.p. 199—201 °C (decomp.) (Found: C, 56.5; H, 6.5; N, 30.0 $C_{11}H_{15}N_5O$ requires C, 56.6; H, 6.5; N, 30.0%); $\nu_{max.}$ 3 440m (NH), 3 400s, (NH), 3 280s (NH), 3 220m sh (NH), 1 700s ($CONH_2$), 1 615s, 1 600s, and 1 585s cm^{-1}; δ_H (90 MHz; $CDCl_3$) 1.01 (t, *J* 7 Hz, 3 H, CH_2Me), 2.1—1.7 (sextet, *J* 7 Hz, 2 H), 2.70 (s, 3 H, CMe), 3.09 (t, 2 H, CH_2), 3.81 (s, 3 H, NMe), 6.37 (br, 1 H, NH), and 8.48 (br, 1 H, NH); *m/z* 233 (M^+, 15.4%); $\lambda_{max.}$(EtOH) 295 (9 050), 251.2 (3 040), 240 (3 090), and 212.8 nm (23 800).

(g) *From 1-(trifluoroacetyl)acetone* (1,1,1-*trifluoropentane*-2,4-*dione*). Dropwise addition of 1-(trifluoroacetyl)acetone (0.18 g, 0.15 cm^3) to a suspension of compound (**9**) (0.1 g, 0.6 mmol) in ethanol (4 cm^3) gave an orange solution, which was left at room temperature for 2 days. Evaporation of the solvent gave the *trifluoromethyl product* (**11d**) (0.12 g, 77%) which was recrystallised from methanol as a white solid, m.p. 270—272 °C (decomp.) (Found: C, 41.8; H, 2.9; N, 27.3; F, 21.8. $C_9H_8F_3N_5O$ requires C, 41.7; H, 3.1; N, 27.0; F, 22.0%); $\nu_{max.}$ 3 470s (NH), 3 265 (NH), 3 190s (NH), 3 120sh (NH), 1 710m, 1 670s ($CONH_2$), 1 650sh, and 1 590s cm^{-1}; *m/z* 259 (M^+, 11.3%); $\lambda_{max.}$(EtOH) 287 (10 200).

Acknowledgements

Thanks are due to S.E.R.C. for financial support to one of us (R. D. C.), and to the Institute Nacional de Investigação Científica, Portugal (M. F. J. R. P. P.) for a study-leave grant.

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Received 14*th July* 1986; *Paper* 6/1392