Chapter 9
Preparation and Characterization of Some Imidazoles and Formimidoyl-1*H*-Imidazoles from Formamidines

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Abstract Imidazole and formimidoyl-1*H*-imidazole derivatives were prepared in good yields by the reaction between formamidines and a weak or strong base depending on reaction conditions. Starting from readily available ethyl (*Z*)-*N*-(2-amino-1,2-dicyanovinyl)formimidate **1**, *N*-aryl-*N*′-[2-amino-1,2-dicyanovinyl] formamidines **2** can be prepared in good yields by the reaction with aromatic amines at room temperature in the presence of an acid catalyst. Treatment of the amidines with the base, DBU (1,8-diazabicyclo[5.4.0]undec-7-ene) at room temperature gave the corresponding 5-amino-1-aryl-4-(cyanoformimidoyl)-1*H*-imidazoles **3** in high yields, whereas the reaction with potassium hydroxide solution afforded the respective 5-amino-4-cyano-1-arylimidazoles **4**. Compounds **4** can also be prepared from compounds **3** by reaction with potassium hydroxide solution. All the derivatives were fully characterized by spectroscopic data**.**

9.1 Introduction

5-Amino-4-cyanoimidazoles have long been recognized as useful synthetic precursors to purines, but there is no simple, general synthesis available for 1-aryl derivatives of these compounds. In 1984, Sen and Mukhopadhyay [1] reported the preparation of 5-amino-4-cyano-1-(*p*-aminosulfonylphenyl)imidazole *via* a multi-step synthesis from the corresponding 1-methyl derivative. Frank and Zeller [2] described the synthesis of a number of 1-aryl- and 1-heteroaryl-5-amino-4-cyanoimidazoles (aryl=2- and 4-ClC_6H_4, 2,4-$Cl_2C_6H_3$, 2,4-$Me_2C_6H_3$; heteroaryl= 2- and 3-pyridyl, 5-Cl-2-pyridyl, 3,5-Cl_2-2-pyridyl, 2-Cl-3-pyridyl, and 2-pyrimidinyl) in low to moderate yields by reaction of the corresponding ethyl *N*-substituted formimidate with 2-aminomalodinitrile tosylate in acetic acid.

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We have been interested in the chemistry of diaminomaleonitrile (DAMN) and its derivatives, in particular, ethyl-2-(2-amino-1,2-dicyanovinyl)formimidate **1**. The latter can be prepared in good yield from the reaction between DAMN and triethyl orthoformate in 1,4-dioxane [3–6]. From our previous work in this area, it appeared to us that **1** would be a useful starting material for the preparation of new *N*-aryl-*N′*–[2-amino-1,2-dicyanovinyl]formamidines **2**. Using procedures developed in our laboratories it was envisaged that these could be readily converted into 5-amino-1-aryl-4-(cyanoformimidoyl)-1*H*-imidazoles **3** [7–13], which are expected to be useful precursors to new 6-carbamoyl-1, 2-dihydropurines and 6-substituted purines [14–20]. In addition, reactions of compound **2** could provide a simple route to the desired 5-amino-1-aryl-4-cyanoimidazoles **4**. The results of this investigation are now reported.

9.2 Experimental

9.2.1 Materials and Methods

All solvents were purified and dried using established procedures. The ^{1}H NMR spectra were recorded on a Bruker XL 500 (500 MHz) instrument, ^{13}C NMR spectra on a DRX-500 AVANCE spectrometer, and IR spectra on a Shimadzu IR-470 spectrophotometer. Mass spectra were recorded on a Kratos Concept instrument. The melting points were measured on an Electrothermal digital melting point apparatus and are uncorrected.

9.2.2 General Procedure for the Preparation of the N-aryl-N′-[2-amino-1,2-dicyanovinyl] formamidines 2a-c

The aromatic amines (5.64 mmol) were added to a suspension of formimidate **1** (5.62 mmol) in dry ethanol or ethyl acetate, which contained anilinium chloride (0.01 g). The mixture was stirred at room temperature until TLC showed that all the formimidate had disappeared (usually 3–4 h) and the amidine was isolated by filtration. In a few cases precipitation had to be assisted by concentrating the solution and addition of a 1:1 mixture of light petroleum (b.p. 40–60 °C) and chloroform. In most cases the products obtained were yellow to pale green. The precipitates were washed with diethyl ether or a light petroleum-chloroform mixture and were dried under vacuum to give the analytically pure products in the yields 82–92 %.

_N_-Phenyl-(_Z_)-_N_′-[2-amino-1,2-dicyanovinyl]formamidine 2a: Recrystallization of the product from dry chloroform/petroleum ether (1:1) gave yellow crystals (1.05 g, 4.97 mmol, 82 %). M.p. 132–134 °C (decomp.). [Found: C, 62.7; H, 4.2; N, 33.0. $C_{11}H_9N_5$ requires: C, 62.6; H, 4.3; N, 33.2 %]; *m*/*z* (EI): 212 $(M + 1)^+$ 100 %, 211 $(M)^+$ 12.5 %, 185 $(M\text{-}CN)^+$ 18.4 %, 106 $[(M + 1)\text{-}C_4H_2N_4]^+$ 2 %, 94 $[(M + 1)\text{-}C_5H_2N_4]^+$ 21 %, 93 $[(M + 1)\text{-}C_5H_3N_4]^+$ 7.5 %; δ_H (500 MHz, d_6-DMSO): 6.60 (br. s, NH_2), 7.10–7.15 (m, 1H, H9), 7.38–7.42 (m, 2H, H8 & H10), 7.55–7.70 (br. s, 2H, H7 & H11), 7.74 (s, 1H, H5), 8.16 (br. s, 1H, NH); δ_C (75 MHz, d_6-DMSO): 151.7 (C5), 143.3 (C6), 133.1 (C8 & C10), 126.8 (C9), 122.9 (C7 & C11), 122.3 (C2), 119.7 and 118.8 (C3 & C4), 109.2 (C1) ppm; ν_{max} (Nujol mull): 3,450 s, 3,420 w, 3,410 w, 3,345 s, 3,300 m, 3,240 w (N-H str.), 2,210 s (CN str.), 2,195 s (CN str.), 1,655 s (C=N str.), 1,600 s (N-H bend), 1,590 s, 1,500 w, 1,320 m, 960 s, 870 s, 730 m cm^{-1}; λ_{max} (EtOH): 202.1 (ε 16631), 205.2 (ε 13869), 262.5 (ε 10989), 262.8 (ε 10894) and 353.0 (ε 32456) nm.

_N_-Benzyl-(_Z_)-_N_′-[2-amino-1,2-dicyanovinyl]formamidine 2b: Recrystallization of the product from dry chloroform/petroleum ether (1:1) gave white crystals (1.22 g, 5.4 mmol, 89 %). M.p. 91–92 °C (decomp.). [Found: C, 64.2; H, 4.9; N, 31.1. $C_{12}H_{11}N_5$ requires: C, 64.0; H, 4.9; N, 31.1 %]; *m*/*z* (EI): 226 $(M + 1)^+$ 100 %, 225 $(M)^+$ 62 %, 199 $(M\text{-}CN)^+$ 11.4 %, 108 $[(M + 1)\text{-}C_5H_2N_4]^+$ 66.0 %; δ_H (500 MHz, d_6-DMSO): 4.52 (d, 2H, $^3J_{6,\,NH}$ 6 Hz, H6), 6.10 (s, 2H, NH_2), 7.20–7.38 (m, 5H, H8, H9, H10, H11 & H12), 7.74 (d, 1H, $^3J_{5,\,NH}$ 6 Hz, H5), 8.18 (br. d, 1H, $^3J_{NH,\,5}$ 6 Hz, NH) ppm; δ_C (75 MHz, d_6-DMSO): 154.4 (C5), 148.8 (C7), 132.4 (C10), 131.8 (C9 & C11), 131.0 (C8 & C12), 121.1 and 120.2 (C3 & C4), 119.2 (C2), 110.1 (C1), 47.9 (C6) ppm; ν_{max} (Nujol mull): 3,460 s, 3,355 s (N-H str.), 2,225 s (CN str.), 2,210 s (CN str.), 1,640 s (C=N str.), 1,600 s (N-H bend), 1,580 m, 1,530 m, 1,350 m, 1,290 m, 1,200 m, 1,170 s, 1,070 m, 960 s, 790 s, 700 s cm^{-1}; λ_{max} (EtOH): 205.3 (ε 22688), 206.6 (ε 1907), 228.0 (ε 20813), 228.1 (ε 1931), 330.1 (ε 39938), and 330.2 (ε 3878) nm.

_N_-(4-Methylphenyl)-(_Z_)-_N_′-[2-amino-1,2-dicyanovinyl]formamidine 2c: Recrystallization of the product from dry chloroform/petroleum ether (1:1) gave pale green crystals (1.35 g, 6.0 mmol, 92 %). M.p. 123–124 °C (decomp.). [Found: C, 63.9; H, 4.8; N, 31.6. $C_{12}H_{11}N_5$ requires: C, 64.0; H, 4.9; N, 31.1 %]; *m*/*z* (EI): 226 $(M + 1)^+$ 100 %, 225 $(M)^+$ 3.0 %, 195 $(M\text{-}CN)^+$ 40.9 %, 120 $[(M + 1)\text{-}C_4H_2N_4]^+$ 6.0 %, 91 $[(M + 1)\text{-}C_5H_4N_5]^+$ 6.0 %; δ_H (500 MHz, d_6-DMSO): 2.50 (s, 3H, CH_3), 6.40 (br. s, NH_2), 6.90 (d, 2H, $^3J_{8,7}$ 8 Hz, H8 & H10), 7.30−7.42 (d, 1H, 6 Hz, H5), 7.50−7.90 (br. complex m, 2H, H7 & H11), 9.90 (br. s, NH) ppm; δ_C (75 MHz, d_6-DMSO): 159.1 (C9), 150.9 (C5), 136.6 (C6), 124.5 (C7 & C11), 122.3 (C2), 119.9 and 118.8 (C3 & C4), 118.1 (C8 & C10), 109.6 (C1), 39.1 (C12) ppm; ν_{max} (Nujol mull): 3,460 w, 3,450 s, 3,340 s, 3,300 m, 3,250 s, 3,120 m (N-H str.), 2,210 s (CN str.), 1,650 s (C=N str.), 1,590 s (N-H bend), 1,575 w, 1,515 m, 1,310 s, 1,295 m, 1,245 s, 1,220 s, 1,175 m, 1,040 s, 960 m, 820 s, 780 m cm^{-1}; λ_{max} (EtOH): 201.1 (ε 14971), 202.2 (ε 15641), 269.0 (ε 12659) and 356.6 (ε 29334) nm.

9.2.3 General Procedure for the Preparation of the 5-Amino-1-aryl-4-(cyanoformimidoyl)-1H-imidazoles 3a-c

To a stirred suspension of the formamidine (1.0 g) in either dry ethyl acetate, ethanol or a 1:1 mixture of ethyl acetate and isopropanol, was added DBU (10 drops) and the reaction was monitored by TLC. After 1–3 h the product precipitated as an off-white to pale yellow solid. This was filtered off, washed with diethyl ether or light petroleum and dried under vacuum to give the title compounds in yields of 85–91 %.

5-Amino-1-phenyl-4-(cyanoformimidoyl)-1*H*-imidazole 3a: Recrystallization of the product from dry chloroform/petroleum ether (1:1) gave pale yellow crystals (0.9 g, 4.2 mmol, 90 %). M.p. 114–116 °C (decomp.). [Found: C, 64.8; H, 4.2; N, 31.0. $C_{11}H_9N_5$ requires: C, 64.9; H, 4.3; N, 30.4 %]; *m*/*z* (EI): 212 $(M + 1)^+$ 3.9 %, 211 $(M)^+$ 14.6 %, 159 $[(M + 1)\text{-CN}]^+$ 14.8 %; δ_H (500 MHz, d_6-DMSO): 6.68 (br. s, 2H, NH_2), 7.42–7.60 (m, 5H, H9, H10, H11, H12 & H13), 7.72 (s, 1H, H2), 11.20 (br. s, 1H, NH) ppm; δ_C (75 MHz, d_6-DMSO): 147.9 (C6), 147.1 (C5), 137.9 (C8), 136.1 (C2), 134.0 (C11), 132.6 (C9 & C13), 128.8 (C10 & C12), 120.5 (C7), 117.6 (C4) ppm; ν_{max} (Nujol mull): 3,340 s, 3,300 m, 3,250 s, 3,180 m, 3,120 m (N-H str.), 2,200 s (CN str.), 1,650 s (C=N str.), 1,600 s (N-H bend), 1,580 s, 1,290 m, 1,230 s, 1,170 m, 960 m, 820 s, 780 m cm^{-1}; λ_{max} (EtOH): 202.0 (ε 20057), 205.4 (ε 13194), 206.2 (ε 13218), 219.9 (ε 13531), 220.2 (ε 14046), 347.2 (ε 9207) and 347.3 (ε 9017) nm.

5-Amino-1-benzyl-4-(cyanoformimidoyl)-1*H*-imidazole 3b: Recrystallization of the product from dry chloroform/petroleum ether gave white crystals (0.85 g, 3.7 mmol, 85 %). M.p. 136–137 °C (decomp.). [Found: C, 64.2; H, 4.8; N, 31.0. $C_{12}H_{11}N_5$ requires: C, 64.0; H, 4.9; N, 31.1 %]; *m*/*z* (EI): 226 $(M + 1)^+$ 100 %, 225 $(M)^+$ 12.6 %, 199 $(M\text{-CN})^+$ 22 %, 91 $(M\text{-}C_5H_4N_5)^+$ 20.8 %; δ_H (500 MHz, d_6-DMSO): 5.10 (s, 2H, H8), 6.76 (br. s, 2H, NH_2), 7.20–7.38 (m, 6H, H10, H11, H12, H13 & H14), 7.42 (s, 1H, H2), 10.88 (br. s, 1H, NH) ppm; δ_C (75 MHz, d_6-DMSO): 148.3 (C6), 147.1 (C5), 140.4 (C9), 136.4 (C2), 132.4 (C12), 131.7 (C11 & C13), 131.2 (C10 & C14), 120.2 (C7), 117.5 (C4), 49.7 (C8); ν_{max} (Nujol mull): 3,350 s, 4,260 s, 3,180 m, 3,120 m (N-H str.), 2,225 s (CN str.), 1,659 s (C=N str.), 1,595 s (N-H bend), 1,550 s, 1,520 m, 1,350 s, 1,300 s, 1,220 s, 1,195 s, 970 s, 940 s, 820 cm^{-1}; λ_{max} (EtOH): 207.5 (ε 15935), 208.5 (ε 16015), 225.0 (ε 12222) and 348.4 (ε 10945) nm.

5-Amino-1-(4-methylphenyl)-4-(cyanoformimidoyl)-1*H*-imidazole 3c: Recrystallization of the product from dry diethyl ether (1:1) gave pale green crystals (0.97 g, 4.02 mmol, 91 %). M.p. 124–125 °C (decomp.). [Found: C, 59.7; H, 4.9; N, 28.9. $C_{12}H_{11}N_5$ requires: C, 59.8; H, 4.6; N, 29.0 %]; *m*/*z* (EI): 242 $(M + 1)^+$ 22 %, 241 $(M)^+$ 55.5 %, 240 $(M\text{-}1)^+$ 27.3 %, 106 $[(M + 1)\text{-}C_5H_4N_5]^+$ 17 %; δ_H (500 MHz, d_6-DMSO): 2.54 (s, 3H, CH_3), 6.72 (br. s, 2H, NH_2), 7.22 (d, 2H, $^3J_{10,9}$ 8 Hz, H10 & H12), 7.46 (s, 1H, H2), 7.54 (d, 2H, $^3J_{13,12}$ 8 Hz, H9 & H13), 11.12 (br. s, 1H, NH) ppm; δ_C (75 MHz, d_6-DMSO): 163.5 (C6), 148.3 (C11), 147.2 (C5), 136.5 (C2), 130.6 (C9 & C13), 130.6 (C8), 120.3 (C7), 119.2 (C10 & C12), 117.5 (C4), 34.4 (C14) ppm; $\nu_{\max}$ (Nujol mull): 3,420 m, 3,260 s, 3,120 m (N-H str.), 2,230 s (CN str.), 1,635 m (C=N str.), 1,600 s (N-H bend), 1,580 s, 1,550 s, 1,525 s, 1,250 s, 1,180 m, 1,170 m, 1,015 s, 930 s, 800 m cm^{-1}; $\lambda_{\max}$ (EtOH): 201.8 (ε 22405), 205.0 (ε 13933), 205.5 (ε 14021), 206.2 (ε 13977), 211.9 (ε 11736), 227.3 (ε 16098), 228.1 (ε 15539), 348.1 (ε 9722) and 348.5 (ε 9571) nm.

9.2.4 General Procedure for the Preparation of the 5-Amino-1-aryl-4-cyanoimidazoles 4a-c

An aqueous solution of 1 M potassium hydroxide (1 ml) was added to a suspension of the formamidine (0.5 g) in ethanol (1 ml) and the mixture was stirred at room temperature for approximately 1 h. The white solid which precipitated was washed with water, a few drops of ethanol and finally diethyl ether before drying under vacuum. The yields of these reactions were 75–90 %.

5-Amino-1-phenyl-4-cyanoimidazole 4a: Recrystallization of the product from a mixture of dry diethyl ether/ethanol (10:1) gave an off-white solid (0.38 g, 2.07 mmol, 90 %). M.p. 194–196 °C (decomp.). [Found: C, 65.1; H, 4.6; N, 30.4. $C_{10}H_8N_4$ requires: C, 65.2; H, 4.3; N, 30.4 %]: *m/z* (EI): 185 $(M + 1)^+$ 5.8 %, 184 $(M)^+$ 24 %, 77 $(M\text{-}C_4H_3N_4)^+$ 12 %; δ_H (500 MHz, d_6-DMSO): 6.20 (s, 2H, NH_2), 7.42 (s, 1H, H2), 7.48–7.68 (m, 5H, H8, H9, H10, H11 & H12) ppm; δ_C (75 MHz, d_6-DMSO): 151.2 (C5), 137.9 (C2), 136.6 (C7), 133.8 (C10), 132.6 (C9 & C11), 129.3 (C8 & C12), 121.1 (C6), 95.0 (C4) ppm; $\nu_{\max}$ (Nujol mull): 3,370 m, 3,300 s, 3,180 s, 3,110 m (N-H str.), 2,210 s (CN str.), 1,680 s (C=N str.), 1,600 s (N-H bend), 1,530 s, 1,265 s, 1,230 s, 1,100 s, 915 s, 780 s, 755 s cm^{-1}; $\lambda_{\max}$ (EtOH): 202.7 (ε 16643), 223.8 (ε 16407), 248.0 (ε 11075) and 346.2 (ε 177) nm.

5-Amino-1-benzyl-4-cyanoimidazole 4b: Recrystallization of the product from a mixture of dry diethyl ether/ethanol (10:1) gave an off-white solid (0.36 g, 1.8 mmol, 82 %). M.p. 197–198 °C (decomp.). [Found: C, 66.7; H, 5.3; N, 28.3. Calc. for $C_{11}H_{10}N_4$: C, 66.7; H, 5.1; N, 28.3 %] ; *m/z* (EI): 199 $(M + 1)^+$ 100 %, 198 $(M)^+$ 4.5 %, 108 $[(M + 1)\text{-}C_7H_7]^+$ 9.6 %; δ_H (500 MHz, d_6-DMSO): 5.12 (s, 2H, CH_2), 6.42 (s, 2H, NH_2), 7.22–7.28 (m, 2H, H10 & H12), 7.32 (s, 1H, H2), 7.34–7.48 (m, 3H, H9, H11 & H13) ppm; δ_C (75 MHz, d_6-DMSO): 152.6 (C5), 140.3 (C8), 136.7 (C2), 132.4 (C11), 131.6 (C10 & C12), 131.5 (C13 & C9), 121.4 (C6), 94.2 (C4), 49.9 (C7) ppm; $\nu_{\max}$ (Nujol mull): 3,380 s, 3,340 w, 3,200 s, 3,100 w (N-H str.), 2,200 s (CN str.), 1,650 s (C=N str.), 1,590 s (N-H bend), 1,530 s, 1,180 s, 1,000 s, 850 m, 800 s cm^{-1}; $\lambda_{\max}$ (EtOH): 202.2 (ε 13538), 245.7 (ε 12771) and 340.0 (ε 250) nm.

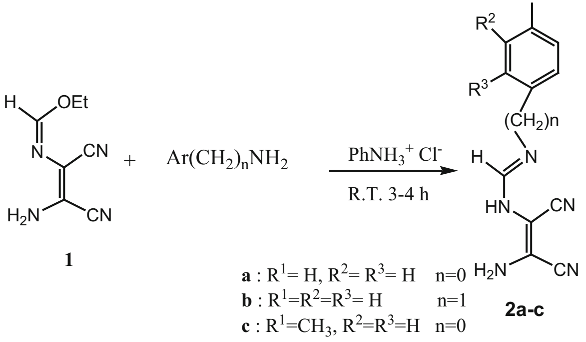
5-Amino-1-(4-methylphenyl)-4-cyanoimidazole 4c: Recrystallization of the product from a mixture of dry diethyl ether/ethanol (10:1) gave a white solid (0.33 g, 1.68 mmol, 75 %). M.p. 167–169 °C (decomp.). [Found: C, 66.3; H, 5.2; N, 28.8.

$C_{11}H_{10}N_4$ requires: C, 66.7; H, 5.1; N, 28.3 %]; *m*/*z* (EI): 198 $(M)^+$ 100 %, 91 $(M\text{-}C_4H_3N_4)^+$ 4.0 %; δ_H (500 MHz, d_6-DMSO): 2.42 (s, 3H, CH_3), 6.12 (s, 2H, NH_2), 7.14 (d, 2H, $^3J_{8,9}$ 9 Hz, H9 & H11), 7.39 (d, 2H, $^3J_{12,11}$ 9 Hz, H8 & H12), 7.41 (s, 1H, H2) ppm; δ_C (75 MHz, d_6-DMSO): 163.4 (C10), 151.5 (C5), 136.8 (C2), 131.1 (C8 & C12), 130.5 (C7), 121.4 (C6), 119.4 (C9 & C11), 94.2 (C4), 35.6 (C13) ppm; ν_{max} (Nujol mull): 3,360 w, 3,340 s, 3,200 s, 3,170 m (N-H str.), 2,240 s (CN str.), 1,650 s (C=N str.), 1,580 s (N-H bend), 1,530 s, 1,260 s, 960 s, 810 s cm^{-1}; λ_{max} (EtOH): 202.5 (ε 12808) and 232.8 (ε 13632) nm.

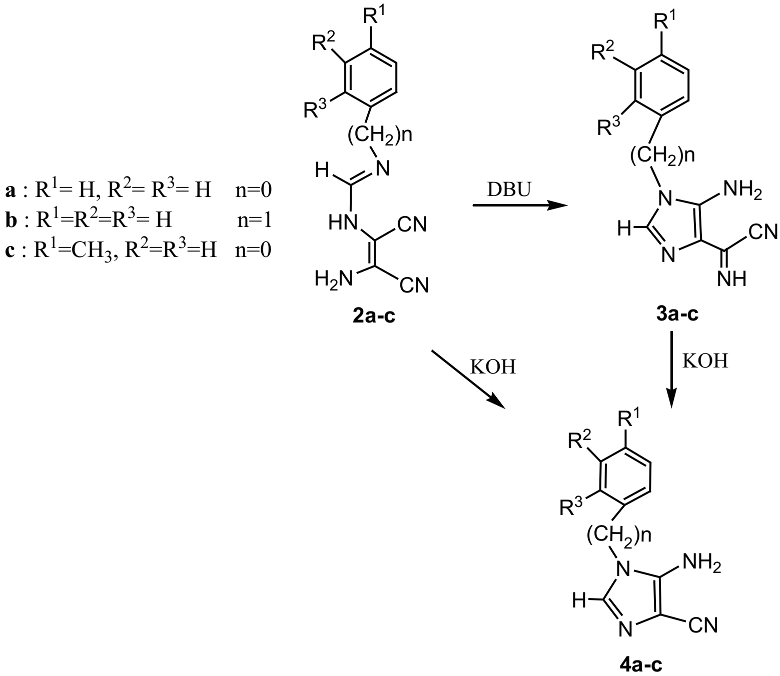
9.3 Results and Discussion

Treatment of **1** with an equimolar amount of the appropriate aromatic amine at room temperature in ethanol in the presence of a catalytic amount of anilinium chloride afforded the corresponding formamidines **2a-c** in 82–92 % yields (Scheme 9.1). Isolation of product was achieved by simple filtration of the final reaction mixture and little or no further purification was required to give analytically pure products. The anilinium chloride is believed to act as a general acid catalyst and a significant acceleration of the rate of reaction was observed. When it is absent, appreciable decomposition occurs and the amidine product becomes difficult to isolate from tarry by-products with consequent low yields. The amine hydrochloride salts of the arylamine reactions also catalyse these reactions, but it is often more convenient to use the anilinium salt.

The spectroscopic data obtained on these compounds **2a-c** were satisfactory. The high resolution mass spectra gave molecular ions at 212, 226, 226 $(M + 1)^+$ consistent with the molecular weights of 211, 225, 225 for the formamidines **2a-c**. The ^1H NMR spectra of compounds **2a-c** in deuterated dimethyl sulfoxide had some interesting features. The HC=N proton appeared at δ 7.30–7.74 ppm and NH proton appeared as a broad singlet at δ 8.16–9.90 ppm and was confirmed by D_2O exchange. The ^{13}C NMR spectra were fully consistent with the assigned structures. The infrared spectra of amidines **2a-c** showed two strong absorptions in the region



Scheme 9.1 Synthetic route toward preparation of formamidines **2a-c**



Scheme 9.2 Synthetic route toward preparation of 5-amino-1-aryl-4-(cyanoformimidoyl) imidazoles **3a-c** and 5-amino-1-aryl-4-cyanoimidazoles **4a-c**

2,210–2,225 cm^{-1} characteristic of C≡N stretching vibrations, together with an NH and a C=N stretching vibrations at 3,100–3,460 cm^{-1} and 1,610–1,650 cm^{-1} respectively.

When several drops of DBU were added to a suspension of the amidines **2a-c** in ethyl acetate or ethanol, cyclization occurred in 1–3 hours to give the corresponding 5-amino-1-aryl-4-(cyanoformimidoyl)imidazoles **3a-c** in good yields (85–91 %). All the compounds were obtained in an analytically pure state and IR spectra showed strong bands in the 2,200–2,230 cm^{-1} region for a C≡N bond and C=N stretching vibrations within the region of 1,660–1,635 cm^{-1}. In all cases, the signals were sharp and in the ^{1}H NMR spectra the CH proton of the imidazole ring appeared in the range δ 7.42–7.72, the NH_2 protons at δ 6.68–6.76 and the NH proton at δ 10.88–11.20 ppm. The ^{13}C NMR spectra were fully consistent with the assigned structures.

When a saturated solution of potassium hydroxide in ethanol was added to a suspension of the amidines **2a-c** in an alcohol at room temperature the corresponding 5-amino-1-aryl-4-cyanoimidazoles **4a-c** were formed in good yields (75–90 %). These compounds can also be made in comparable yields by the reaction of the compounds **3a-c** with a saturated solution of potassium hydroxide in ethanol under conditions similar to those described above (Scheme 9.2).

Compounds **4a-c** were recrystallised from a mixture of ethanol/methanol (1:1) and gave pale yellow to off-white crystals respectively. These were fully characterized by microanalysis, IR, ^{1}H, ^{13}C NMR and mass spectroscopy. The high resolution mass spectra gave molecular ions at 185, 199, 199 $(M + 1)^+$ consistent with the expected molecular weights of 184, 198 and 198 for the imidazoles **4a-c**. The infrared spectra confirmed the presence of the NH and C=N stretching vibrations within the region of 3,100–3,380 cm^{-1} and 1,650–1,680 cm^{-1} respectively. The infrared spectra also showed sharp absorption bands within the range of 2,210–2,240 cm^{-1} for the C≡N stretching vibration. In the ^{1}H NMR spectra of the isolated 5-amino-1-aryl-4-cyanoimidazoles, the primary amine protons were observed in the region of δ 6.12–6.42 ppm and in several cases the assignment was confirmed by D_2O exchange. The protons of the imidazole rings appeared as sharp singlets in the range of δ 7.34–7.42 ppm. The ^{13}C NMR spectra of the compounds **4a-c** had the expected number of peaks. The signal for the C-2 carbon of the imidazole ring appeared in the region of 136.7–137.9 ppm.

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