Enaminonitrile in Heterocyclic Synthesis: Synthesis and Reactions of Some Pyrimidine Derivatives

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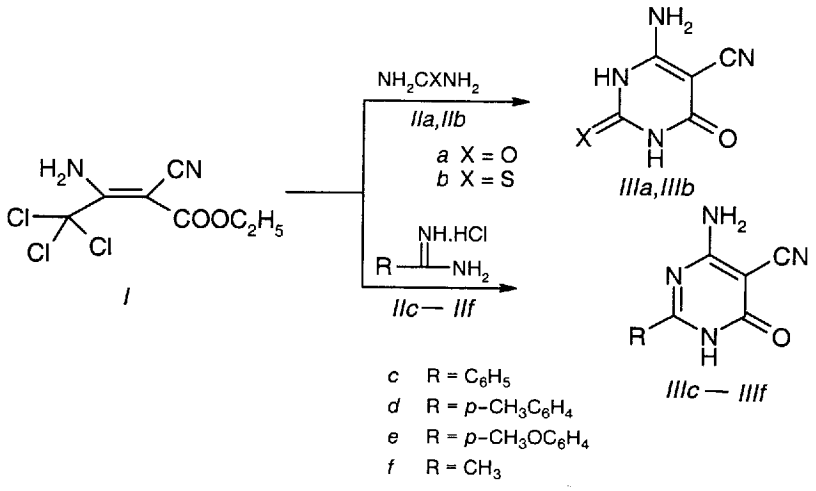
Several new pyrimidine derivatives were synthesized by the reaction of β-trichloromethyl-β-enamino ester with urea, thiourea or some amidines in the presence of triethylamine. They were further subjected to ring formation affording pyrimido[4,5-*d*]pyrimidine, pyrazolo[3,4-*d*]pyrimidine, thiazolo[2,3-*b*]pyrimidine and its arylidene 1,4,6,8,9,10a-hexaphenanthrene derivatives.

Pyrimidine derivatives play an important role in several biological and pharmacological active substances such as antibacterial and antitumour agents as well as agrochemical and veterinary products [1—7].

Synthesis of functionalized β-amino α,β-unsaturated esters and nitriles by nucleophilic vinylic substitution was reported [8]. *Gavrilenko* and *Miller* [9] have reported that β-trichloromethyl-β-enamino esters react with hydrazine hydrate *via* elimination of chloroform to yield the corresponding amidrazones. In the previous work [10], ethyl-2-amino-2-trichloromethylcrotonate reacted with *N*-tosyl-3-aminopyrazole to yield pyrazolopyrimidine derivative.

The aim of this work is the synthesis of pyrimidine derivatives through the reaction of ethyl 2-amino-2-trichloromethylcrotonate (*I*) [9] with urea (*IIa*), thiourea (*IIb*) or some amidines. Thus, compound *I* reacted with *IIa via* nucleophilic vinylic substitution, elimination of chloroform followed by cyclization and elimination of ethanol to yield (1,3*H*)-4-amino-5-cyanopyrimidine-2,6-dione (*IIIa*) (Scheme 1). A similar mechanism has been recently suggested for the reaction of enaminonitriles with cyclic amidines [11]. In accordance with the above structure, the ^{1}H NMR spectrum revealed singlet at δ = 11.85 for NH, broad singlet at δ = 5.2 for protons of NH_2. Similarly to the above reported reaction, a mixture of *I* and *IIb* was refluxed in the presence of triethylamine to afford (1,3*H*)-4-amino-5-cyano-2-thioxopyrimidin-6-one (*IIIb*).

Compound *I* and amidine chloride *IIc—IIf* were re-



Scheme 1

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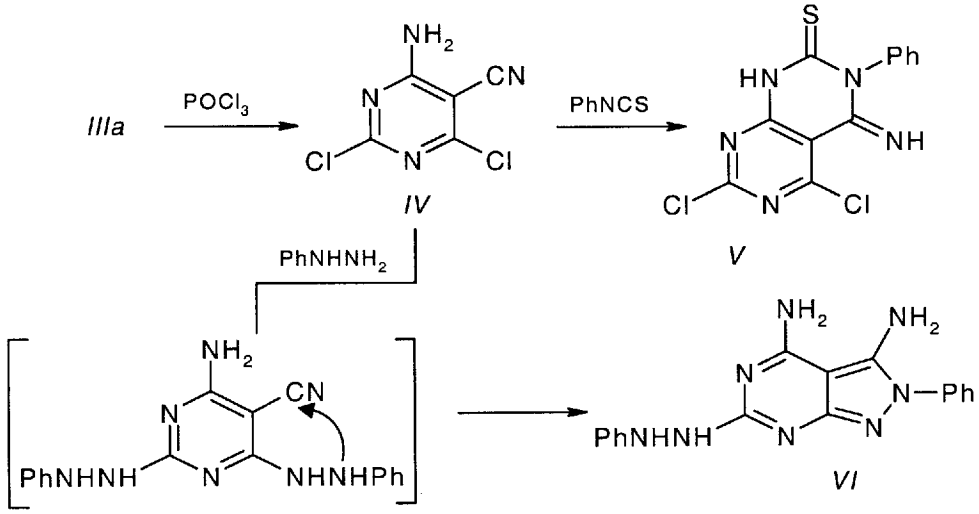


Scheme 2

fluxed in the presence of triethylamine to afford 2-substituted (1*H*)-4-amino-5-cyanopyrimidin-6-one derivatives *IIIc—IIIf* the structures of which were in agreement with their spectral data. These derivatives were subjected to further ring formation. Thus, the reaction of *IIIa* with phosphorous oxychloride yielded 4-amino-5-cyano-2,6-dichloropyrimidine (*IV*) (Scheme 2).

Compound *IV* reacted with phenylisothiocyanate [12, 13] to yield (5,8*H*)-2,4-dichloro-5-imino-6-phenylpyrimido[4,5-*d*]pyrimidine-7-thione (*V*) in excellent yield. On the other hand, compound *IV* reacted with two moles of phenylhydrazine to afford 3,4-diamino-2-phenyl-6-(N´-phenylhydrazino)-2*H*-pyrazolo[3,4-*d*]pyrimidine (*VI*) through cyclization of 4-amino-5-cyano-2,6-di(N´-phenylhydrazino)pyrimidine under the reaction conditions [14].

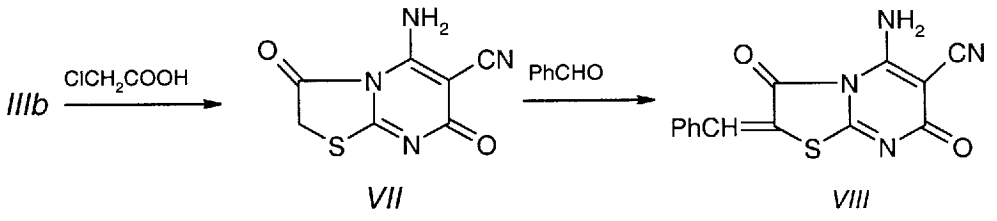
Compound *IIIb* reacted with chloroacetic acid to yield (2*H*)-5-amino-6-cyano-3,7-dioxothiazolo[2,3-*b*]-pyrimidine (*VII*) which on reaction with benzaldehyde in the presence of $NaOC_2H_5$ afforded arylidene derivative *VIII* (Scheme 3).

The reaction of *IIIc* with phosphorous oxychloride yielded 4-amino-6-chloro-5-cyano-2-phenylpyrimidine (*IX*) which on reaction with triethyl orthoformate in acetic anhydride [15] yielded ethyl *N*-(4-chloro-5-cyano-2-phenylpyrimid-6-yl)methanimidate (*X*) (Scheme 4). Reaction of *X* with hydrazine hydrate afforded (3*H*)-3-amino-5-chloro-4-imino-7-phenylpyrimido[4,5-*d*]pyrimidine (*XI*) through cyclization to form 6-membered amino derivative [16, 17]. The structure of compound *XI* was confirmed by reaction with pyruvic acid [15] to afford (3*H*)-5-chloro-2-methyl-3-oxo-7-phenyl-1,4,6,8,9,10a-hexaazaphenanthrene (*XII*) through cyclization.

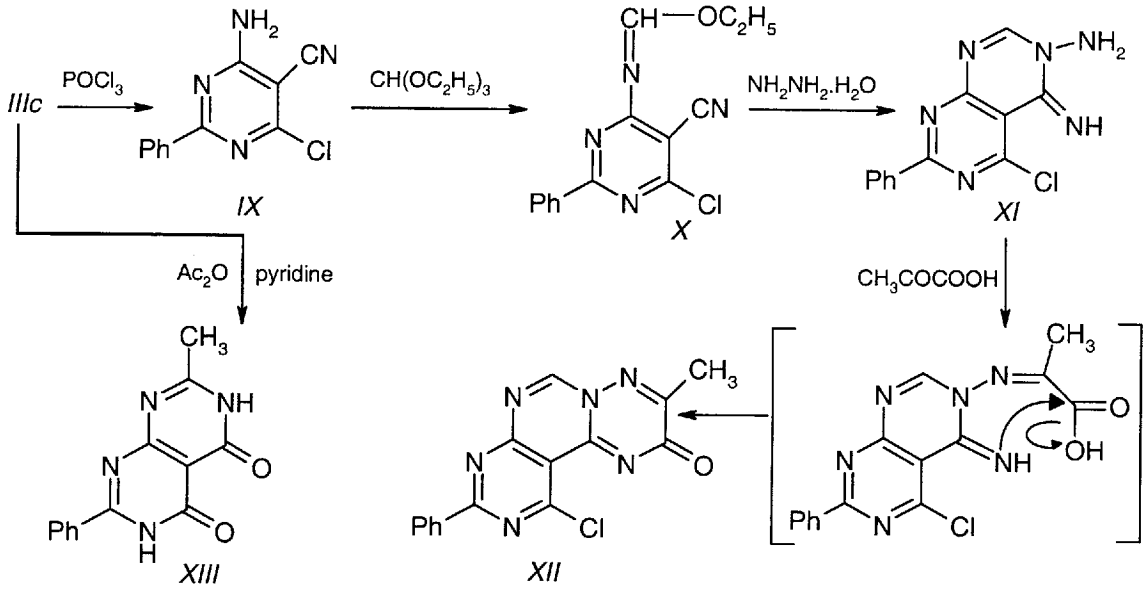
On the other hand, compound *IIIc* reacted with acetic anhydride in the presence of pyridine [18] to yield (3,6*H*)-4,5-dioxo-2-methyl-7-phenylpyrimido[4,5-*d*] pyrimidine (*XIII*). Thus, structure *XIII* is supported by its mass spectra which revealed a molecular formula $C_{13}H_{10}N_4O_2$ (M^+ = 254) and ^1H NMR spectra which included one single band near δ = 2.54 assigned to the three CH_3 protons, single band near δ = 11.99 for one NH proton exchangeable with D_2O, and multiplet at δ = 7.5—8.2 for the five phenyl protons.

EXPERIMENTAL

Melting points were determined on a Gallenkamp electrothermal apparatus and are uncorrected. The IR spectra were recorded on a Pye—Unicam SP 110 spectrophotometer as KBr disks. The ^1H and ^{13}C NMR spectra were recorded on a Varian Gemini NMR spectrometer using DMSO-d_6 solutions and Me_4Si as an internal reference. Mass spectra were measured on GC/MS-QP 1000 Ex mass spectrometer at 70 eV. The purity of the



Scheme 3



Scheme 4

prepared compounds was confirmed using thin-layer chromatography (TLC). Precoated silica gel plates (F254, Merck, Darmstadt) were used for TLC.

Pyrimidine Derivatives *IIIa—IIIf*

Compound *I* (0.01 mol) and urea *IIa*, thiourea *IIb* or amidine chloride *IIc—IIf* (0.01 mol) were refluxed in ethanol (50 cm^3) with triethylamine (0.5 cm^3) for 4 h. The solvent was then evaporated *in vacuo* and the remaining product was triturated with water (20 cm^3) and then acidified with HCl. The resulting solid product was collected by filtration and crystallized from ethanol.

IIIa: Yield = 1.11 g (73 %), m.p. > 300 °C (ethanol). For $C_5H_4N_4O_2$ (M_r = 152.11) w_i(calc.): 39.48 % C, 2.65 % H, 36.83 % N; w_i(found): 39.38 % C, 2.60 % H, 36.80 % N. IR spectrum (KBr), $\tilde{\nu}/cm^{-1}$: 2225 (CN), 1693 (C=O), 3210 (NH_2), 3420 (NH). ^{1}H NMR spectrum (200 MHz, DMSO-d_6), δ: 11.85 (s, 1H, NH), 5.2 (br, s, 2H, NH_2). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 116.4 (CN), 134.2 (C), 138.4 (C), 162.7 (CO), 168.8 (CO). Mass spectrum, *m/z* (I_r/%): 152 (66.4).

IIIb: Yield = 1.29 g (77 %), m.p. > 300 °C (ethanol). For $C_5H_4N_4OS$ (M_r = 168.17) w_i(calc.): 35.70 % C, 2.39 % H, 33.31 % N; w_i(found): 35.59 % C, 2.35 % H, 33.29 % N. IR spectrum (KBr), $\tilde{\nu}/cm^{-1}$: 3415 (NH), 3230 (NH_2), 1195 (C=S), 2222 (CN), 1705 (C=O). ^{1}H NMR spectrum (200 MHz, DMSO-d_6), δ: 11.78 (s, 1H, NH), 5.1 (br, s, 2H, NH_2). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 114.8 (CN), 134.3 (C), 137.8 (C), 169.7 (CO), 182.6 (CS). Mass spectrum, *m/z* (I_r/%): 168 (73.2).

IIIc: Yield = 1.69 g (80 %), m.p. = 308 °C (ethanol). For $C_{11}H_8N_4O$ (M_r = 212.21) w_i(calc.): 62.25 % C, 3.79 % H, 26.40 % N; w_i(found): 62.13 % C, 3.74 % H, 26.33 % N. IR spectrum (KBr), $\tilde{\nu}/cm^{-1}$: 1643 (C_6H_5), 3410 (NH), 1695 (C=O), 2225 (CN), 3215 (NH_2). ^{1}H NMR spectrum (200 MHz, DMSO-d_6), δ: 11.65 (s, 1H, NH), 4.7 (br, s, 2H, NH_2), 7.16—7.32 (m, 5H, Ph). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 115.3 (CN), 130.4 (CH), 132.3 (2CH), 132.6 (CH), 133.5 (CH), 134.3 (C), 136.5 (C), 137.7 (C), 139.4 (C), 168.7 (CO). Mass spectrum, *m/z* (I_r/%): 212 (55.6).

IIId: Yield = 1.85 g (82 %), m.p. = 325 °C (ethanol). For $C_{12}H_{10}N_4O$ (M_r = 226.23) w_i(calc.): 63.70 % C, 4.45 % H, 24.76 % N; w_i(found): 63.67 % C, 4.38 % H, 24.72 % N. IR spectrum (KBr), $\tilde{\nu}/cm^{-1}$: 3426 (NH), 1684 (C=O), 2224 (CN), 3220 (NH_2). ^{1}H NMR spectrum (200 MHz, DMSO-d_6), δ: 11.78 (s, 1H, NH), 5.2 (br, s, 2H, NH_2, D_2O exchangeable), 7.96—8.68 (m, 4H, C_6H_4), 3.4 (s, 3H, CH_3). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 17.8 (CH_3), 114.9 (CN), 131.3 (C), 132.9 (2CH), 133.5 (CH), 133.8 (CH), 135.6 (C), 136.7 (C), 138.4 (C), 140.6 (C), 166.3 (CO). Mass spectrum, *m/z* (I_r/%): 226 (77.2).

IIIe: Yield = 1.91 g (79 %), m.p. = 314 °C (ethanol). For $C_{12}H_{10}N_4O_2$ (M_r = 242.23) w_i(calc.): 59.50 % C, 4.16 % H, 23.12 % N; w_i(found): 59.31 % C, 4.11 % H, 23.09 % N. IR spectrum (KBr), $\tilde{\nu}/cm^{-1}$: 3415 (NH), 1680 (C=O), 2226 (CN), 3225 (NH_2). ^{1}H NMR spectrum (200 MHz, DMSO-d_6), δ: 11.77 (s, 1H, NH), 5.4 (br, s, 2H, NH_2, D_2O exchangeable), 8.02—8.63 (m, 4H, C_6H_4), 4.02 (s, 3H, OCH_3). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 22.8 (OCH_3), 116.5 (CN), 130.6 (C), 131.7 (2 CH), 132.1 (CH), 133.8 (CH), 134.6 (C), 135.9 (C), 137.6 (C), 141.3 (C), 168.2 (CO). Mass spectrum, *m/z* (I_r/%): 242 (48.8).

IIIf: Yield = 1.02 g (68 %), m.p. = 305 °C (ethanol). For $C_6H_6N_4O$ (M_r = 150.14) w_i(calc.): 47.99 % C, 4.02 % H, 37.31 % N; w_i(found): 47.87 % C, 3.94 % H, 37.31 % N. IR spectrum (KBr), $\tilde{\nu}/cm^{-1}$: 3410 (NH), 1670 (C=O), 2225 (CN), 3230 (NH_2). ^{1}H NMR spectrum (200 MHz, DMSO-d_6), δ: 11.74 (s, 1H, NH), 5.3 (br, s, 2H,

NH_2), 2.3 (s, 3H, CH_3). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 22.5 (CH_3), 114.8 (CN), 130.7 (C), 134.2 (C), 137.5 (C), 167.8 (CO). Mass spectrum, m/z (I_r/%): 150 (50.7).

4-Amino-5-cyano-2,6-dichloropyrimidine (*IV*)

A mixture of *IIIa* (1.52 g; 0.01 mol), 20 cm^3 of phosphorous oxychloride, and 2 cm^3 of *N*,*N*-dimethylaniline was refluxed for 3 h. After removal of the excess of phosphorous oxychloride, 200 cm^3 of ice water was added into the residue. The precipitate was collected by filtration and recrystallized from ethanol. Yield = 1.56 g (83 %), m.p. = 175 °C (ethanol). For $C_5H_2N_4Cl_2$ (M_r = 189.00) w_i(calc.): 31.77 % C, 1.06 % H, 29.64 % N; w_i(found): 31.66 % C, 1.02 % H, 29.55 % N. IR spectrum (KBr), $\tilde{\nu}$/cm^{-1}: 3227 (NH_2), 2230 (CN), 700 (C—Cl). ^1H NMR spectrum (200 MHz, DMSO-d_6), δ: 5.4 (br, s, 2H, NH_2). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 115.8 (CN), 137.6 (C), 141.8 (C), 143.4 (C), 144.8 (C). Mass spectrum, m/z (I_r/%): 189 (83.5).

(5,8*H*)-2,4-Dichloro-5-imino-6-phenylpyrimido[4,5-*d*]pyrimidine-7-thione (*V*)

A mixture of *IV* (1.88 g; 0.01 mol), phenylisothiocyanate (0.01 mol), and pyridine (5 cm^3) was kept at room temperature for 72 h. The reaction mixture was then poured into water (100 cm^3) containing glacial acetic acid (5 cm^3). The resulting solid was washed with water, dried and recrystallized from ethanol. Yield = 2.85 g (88 %), m.p. = 145 °C (ethanol). For $C_{12}H_7N_5SCl_2$ (M_r = 324.18) w_i(calc.): 44.45 % C, 2.17 % H, 21.60 % N; w_i(found): 44.38 % C, 2.13 % H, 21.51 % N. IR spectrum (KBr), $\tilde{\nu}$/cm^{-1}: 3420 (NH), 1190 (C=S), 1645 (Ph), 694 (C—Cl), 1608 (C=N). ^1H NMR spectrum (200 MHz, DMSO-d_6), δ: 11.68 (s, 1H, $NH_{pyrimidine}$), 5.2 (br, s, 1H, NH), 7.25—7.43 (m, 5H, Ph). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 105.4 (C), 116.3 (C), 126.7 (C), 129.6 (CH), 130.4 (CH), 132.5 (CH), 133.9 (CH), 134.3 (CH), 136.2 (C), 137.4 (C), 141.5 (C), 182.6 (CS). Mass spectrum, m/z (I_r/%): 324 (62.3).

3,4-Diamino-2-phenyl-6-(N′-phenylhydrazino)-2*H*-pyrazolo[3,4-*d*]pyrimidine (*VI*)

A mixture of *IV* (1.88 g; 0.01 mol) and phenylhydrazine (2.16 g; 0.02 mol) was heated at 120 °C for 3 h. After cooling 100 cm^3 of ice water was added into the mixture. The product was filtered, washed with water and recrystallized from methanol. Yield = 2.22 g (67 %), m.p. = 190 °C (methanol). For $C_{17}H_{16}N_8$ (M_r = 332.36) w_i(calc.): 61.43 % C, 4.85 % H, 33.71 % N; w_i(found): 61.40 % C, 4.76 % H, 33.70 % N. IR spectrum (KBr), $\tilde{\nu}$/cm^{-1}: 3234, 3255 (NH_2), 1642 (Ph), 3310 (NH). ^1H NMR spectrum (200 MHz, DMSO-d_6), δ: 5.2 (d, J = 5 Hz, 1H, NH), 5.8 (m, 1H, NH), 7.35—7.62 (m, 5H, Ph), 4.6—4.8 (br, s, 2H, NH_2). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 119.6 (C), 121.9 (C), 123.4 (C), 125.7 (C), 127.9 (C), 128.4 (2CH), 130.1 (2CH), 132.9 (2CH), 134.3 (2CH), 135.7 (2CH), 137.5 (C), 138.8 (C). Mass spectrum, m/z (I_r/%): 332 (35.7).

(2*H*)-5-Amino-6-cyano-3,7-dioxothiazolo-[2,3-*b*]pyrimidine (*VII*)

A mixture of *IIIb* (1.68 g; 0.01 mol), chloroacetic acid (1.5 cm^3), and ethanol (50 cm^3) was refluxed for 6 h. After cooling, the solid product formed was collected and recrystallized from benzene—ethanol (volume ratio = 3 : 1). Yield = 1.89 g (91 %), m.p. = 296 °C (benzene—ethanol, volume ratio = 3 : 1). For $C_7H_4N_4O_2S$ (M_r = 208.20) w_i(calc.): 40.38 % C, 1.93 % H, 26.91 % N; w_i(found): 40.31 % C, 1.91 % H, 26.82 % N. IR spectrum (KBr), $\tilde{\nu}$/cm^{-1}: 1692 (C=O), 2228 (CN), 3265 (NH_2). ^1H NMR spectrum (200 MHz, DMSO-d_6), δ: 3.34 (s, 2H, CH_2), 5.4 (br, s, 2H, NH_2). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 26.4 (CH_2), 116.8 (CN), 129.4 (C), 131.2 (C), 137.4 (C), 162.2 (CO), 166.3 (CO). Mass spectrum, m/z (I_r/%): 208 (27.8).

2*H*-5-Amino-6-cyano-3,7-dioxo-2-phenylmethylenethiazolo[2,3-*b*]pyrimidine (*VIII*)

A mixture of *VII* (2.08 g; 0.01 mol) in benzene (30 cm^3), benzaldehyde (1.5 cm^3), and sodium ethoxide solution (5 cm^3) was refluxed for 4 h. After cooling and filtration, the precipitate was crystallized from ethanol. Yield = 2.42 g (82 %), m.p. = 318 °C (ethanol). For $C_{14}H_8N_4O_2S$ (M_r = 296.30) w_i(calc.): 56.75 % C, 2.72 % H, 18.90 % N; w_i(found): 56.72 % C, 2.65 % H, 18.82 % N. IR spectrum (KBr), $\tilde{\nu}$/cm^{-1}: 1683 (C=O), 2227 (CN), 3450 (NH_2), 1625 (Ph). ^1H NMR spectrum (200 MHz, DMSO-d_6), δ: 5.3 (br, s, 2H, NH_2), 8.4 (s, 1H, CH), 7.96—8.15 (m, 5H, Ph). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 116.8 (CN), 118.7 (CH), 129.4 (C), 129.6 (CH), 130.4 (CH), 131.2 (C), 132.8 (CH), 132.5 (CH), 133.9 (CH), 134.3 (C), 136.2 (C), 137.4 (C), 161.2 (CO), 165.4 (CO). Mass spectrum m/z (I_r/%): 295 (48.1).

4-Amino-6-chloro-5-cyano-2-phenylpyrimidine (*IX*)

A mixture of *IIIc* (2.52 g; 0.01 mol), phosphorous oxychloride (20 cm^3), and *N*,*N*-dimethylaniline (2 cm^3) was refluxed for 3 h. After removal of the excess of phosphorous oxychloride, 200 cm^3 of ice water was added into the residue. The precipitate was collected by filtration and recrystallized from ethanol. Yield = 2.14 g (93 %), m.p. = 174 °C (ethanol). For $C_{11}H_7N_4Cl$ (M_r = 230.65) w_i(calc.): 57.28 % C, 3.05 % H, 24.29 % N; w_i(found): 57.21 % C, 3.01 % H, 24.22 % N. IR spectrum (KBr), $\tilde{\nu}$/cm^{-1}: 1650 (Ph), 708 (C—Cl), 2228 (CN), 3255 (NH_2). ^1H NMR spectrum (200 MHz, DMSO-d_6), δ: 5.4 (br, s, 2H, NH_2), 7.46—7.75 (m, 5H, Ph). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 114.7 (CN), 124.3 (C), 126.7 (C), 129.6 (CH), 130.4 (CH), 132.5 (CH), 133.9 (CH), 134.3 (CH), 136.2 (C), 137.4 (C), 141.5 (C). Mass spectrum m/z (I_r/%): 230 (32.6).

Ethyl *N*-(4-Chloro-5-cyano-2-phenylpyrimid-6-yl)methanimidate (*X*)

A mixture of *IX* (2.305 g; 0.01 mol), an equimolar amount of triethyl orthoformate, and acetic anhydride (16 cm^3) was refluxed for 5 h. The solvent was removed under reduced pressure. The resulting solid product was crystallized from benzene—petroleum ether (volume ratio = 1 : 1). Yield = 2.40 g (84 %), m.p. = 136 °C (benzene—petroleum ether (volume ratio = 1 : 1)). For $C_{14}H_{11}N_4OCl$ (M_r = 286.72) w_i(calc.): 58.64 % C, 3.86 % H, 19.54 % N; w_i(found): 58.60 % C, 3.77 % H, 19.47 % N. IR spectrum (KBr), $\tilde{\nu}/cm^{-1}$: 2226 (CN), 1658 (Ph), 715 (C—Cl),1610 (C=N). ^1H NMR spectrum (200 MHz, DMSO-d_6), δ: 4.3 (q, 2H, J = 6 Hz, CH_2), 1.38 (t, 3H, J = 6 Hz, CH_3), 7.54—8.07 (m, 5H, Ph), 8.18 (s, ^1H, CHOEt). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 17.3 (CH_3), 22.5 (CH_2O), 114.7 (CN), 124.3 (C), 126.7 (C), 129.6 (CH), 130.4 (CH), 132.5 (CH), 133.9 (CH), 134.3 (CH), 136.2 (C), 137.4 (C), 138 (CH), 141.5 (C). Mass spectrum, m/z (I_r/%): 286 (22.6).

(3*H*)-3-Amino-5-chloro-4-imino-7-phenylpyrimido[4,5-*d*]pyrimidine (*XI*)

To a solution of *X* (2.865 g; 0.01 mol) in benzene (20 cm^3), hydrazine hydrate (5 cm^3 in 10 cm^3 of H_2O) was added and the reaction mixture was stirred for 60 h, then allowed to stand overnight. The precipitate formed was filtered off, dried and recrystallized from benzene. Yield = 2.01 g (74 %), m.p. = 212 °C (benzene). For $C_{12}H_9N_6Cl$ (M_r = 272.69) w_i(calc.): 52.85 % C, 3.32 % H, 30.81 % N; w_i(found): 52.80 % C, 3.24 % H, 30.75 % N. IR spectrum (KBr), $\tilde{\nu}/cm^{-1}$: 1648 (Ph), 3247 (NH_2), 3390 (NH), 705 (C—Cl), 1604 (C=N). ^1H NMR spectrum (200 MHz, DMSO-d_6), δ: 7.68—8.32 (m, 5H, Ph), 5.2 (br, s, 1H, NH), 6.3 (br, s, 2H, NH_2), 8.3 (s, 1H, $H_{pyrimidine}$). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 120.8 (C), 121.7 (CH), 123.8 (C), 124.9 (C), 127.3 (C), 128.6 (CH), 129.7 (CH), 132.2 (CH), 134.3 (CH), 135.7 (CH), 137.5 (C), 142.8 (C). Mass spectrum, m/z (I_r/%): 272 (41.2).

(3*H*)-5-Chloro-2-methyl-3-oxo-7-phenyl-1,4,6,8,9,10a-hexaazaphenanthrene (*XII*)

To a solution of *XI* (2.725 g; 0.01 mol) in absolute ethanol (100 cm^3) pyruvic acid (0.01 mol) was added and the mixture was refluxed for 5 h. After cooling and filtration, the precipitated product was crystallized from ethanol. Yield = 2.17 g (67 %), m.p. = 323 °C (ethanol). For $C_{15}H_9N_6OCl$ (M_r = 324.73) w_i(calc.): 55.48 % C, 2.79 % H, 25.88 % N; w_i(found): 55.41 % C, 2.69 % H, 25.81 % N. IR spectrum (KBr), $\tilde{\nu}/cm^{-1}$: 1690 (C=O), 707 (C—Cl), 1644 (Ph). ^1H NMR spectrum (200 MHz, DMSO-d_6), δ: 2.03 (s, 3H, CH_3), 8.2 (s, 1H, $H_{pyrimidine}$), 7.63—8.25 (m, 5H, Ph). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 16.4 (CH_3), 120.8 (C), 121.7 (CH), 123.8 (C), 124.9 (C), 127.3 (2C), 128.6 (CH), 129.7 (CH), 132.2 (CH), 134.3 (CH), 135.7 (CH), 137.5 (C), 141.8 (C), 162.6 (CO). Mass spectrum, m/z (I_r/%): 324 (56.4).

(3,6*H*)-4,5-Dioxo-2-methyl-7-phenylpyrimido-[4,5-*d*]pyrimidine (*XIII*)

A solution of *IIIc* (0.01 mol) in an acetic anhydride—pyridine mixture [19] (volume ratio = 2 : 1) was heated at 80 °C for 6 h, then cooled and poured into ice water. The product was collected by filtration, washed with water, and recrystallized from ethanol. Yield = 2.36 g (93 %), m.p. > 350 °C (ethanol). For $C_{13}H_{10}N_4O_2$ (M_r = 254.24) w_i(calc.): 61.41 % C, 3.96 % H, 22.03 % N; w_i(found): 61.36 % C, 3.89 % H, 21.98 % N. IR spectrum (KBr), $\tilde{\nu}/cm^{-1}$: 1718 (C=O), 1657 (Ph), 3435 (NH). ^1H NMR spectrum (200 MHz, DMSO-d_6), δ: 7.58—8.16 (m, 5H, Ph), 11.99 (s, 1H, NH, D_2O exchangeable), 2.14 (s, 3H, CH_3). ^{13}C NMR spectrum (75.5 MHz, DMSO-d_6), δ: 17.8 (CH_3), 122.6 (C), 123.8 (C), 124.4 (C), 127.7 (C), 128.6 (CH), 129.4 (CH), 131.5 (CH), 132.9 (CH), 134.8 (CH), 137.6 (C), 162.7 (CO), 163.4 (CO). Mass spectrum, m/z (I_r/%): 254 (96.8).

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