



Novel heterocyclic β -nitroenamines-based on a one-pot three-component reaction: a facile synthesis of fully substituted 1*H*-pyrrolo[1,2-*a*]-fused-1,3-diazaheterocycles

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ABSTRACT

A one-pot multicomponent synthesis of a novel class of 2,3-dihydro-1*H*-pyrrolo[1,2-*a*]imidazoles, 1,2,3,4-tetrahydropyrrolo[1,2-*a*]pyrimidines, and 2,3,4,5-tetrahydro-1*H*-pyrrolo[1,2-*a*][1,3]diazepines, starting from simple and readily available inputs including diveres diamines, 1,1-bis(methylthio)-2-nitroethen and diaroylacetylene, in excellent yields is described.

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1. Introduction

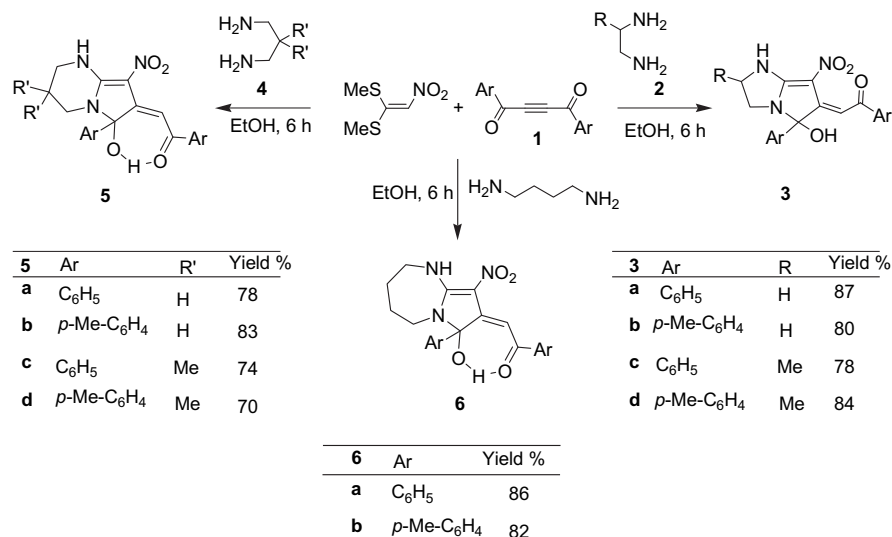
Heterocyclic compounds are important natural and synthetic materials. The remarkable ability of heterocyclic cores to serve both as biomimetics and active pharmacophores has largely contributed to their unique value as traditional key elements of numerous drugs and designed medicinal agents in medicinal chemistry.¹ In particular, nitrogen containing heterocycles are prevalent in many drugs,² thus synthetic chemists are increasingly motivated to discover new methods for rapid construction of pharmacologically important drug-like compounds.³ Amongst them, the pyrroloimidazole, pyrrolopyrimidine, and pyrrolodiazepine scaffolds have been used for both synthetic and clinical studies. Pyrroloimidazoles are useful in the treatment of hypoalkemia, hypertension, and congestive heart failure.⁴ Compounds containing the imidazole moiety have many pharmacological properties and play important roles in biochemical processes.⁵ Pyrrolopyrimidine nucleoside derivatives are reported to have various biological activities, such as anti-HCV, anti-HIV type 1, and anti-HSV as well as being adenosine kinase, aurora-A kinase, and cAMP phosphodiesterase inhibitors.^{6–9} Naturally occurring mycalisine A, cadeguomycin, and

2-deoxycadeguomycin^{10,11} also posses a pyrrolo[2,3-*a*]pyrimidine moiety. A number of pyrrolopyrimidine derivatives structurally related to toyocamycin, sangivamycin, and the seco nucleosides of tubercidin have antiviral activity.^{12,13} The diazepine nucleus is a pharmacophoric scaffold and many diazepines have recently received great attention, because of their wide range of therapeutic and pharmacological properties. Many members of the diazepine family are widely used as antianxiety, antidepressant, sedative, hypnotic, tranquilizing, anticonvulsant, antihistaminic, analgesic, and anti-inflammatory agents.^{14,15}

The development of new approaches for the efficient construction of these heterocycles continues to be essential for accessing natural products and their structural analogues. Accordingly, and because of their scarce occurrence in exotic organisms, novel strategies for the synthesis of these *N*-heterocycles have received considerable attention in the past decades.¹⁶ Heterocyclic enamines are versatile building blocks for the synthesis of various bicyclic and tricyclic structures bearing a bridgehead nitrogen atom. Among them, cyclic β -nitroenamines, which consist of push–pull ethylene systems with two donors (amine) at the two ends and an acceptor (nitro) at the other end of the ethylene, manifest themselves as common enamines in electrophilic reactions and could react with a variety of electrophiles, with electrophilic attack proceeding at either or both of two nucleophilic centers.^{17–21} The high solubility of the nitroenamines in general

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organic solvents enables chemists to conduct reactions in the organic media accompanied by easy experimental manipulations and considerable safety. Although several nitroenamines have been known for a long time, apart from a few reactions,^{22–24} they have not been used in organic synthesis. In the course of our research program into design of new routes for the synthesis of a variety of active biologically nitrogen heterocycles in our laboratory via one-pot synthesis and reactions of enamines,²⁵ we become interested in the application of 1,1-bis(methylthio)-2-nitroethene for preparation of cyclic β -nitroenamines and their behavior in one-pot multi-component reaction. Our strategy to reach this goal is outlined in Scheme 1.



Scheme 1. The reaction of diamine, 1,1-bis(methylthio)-2-nitroethene and diaroylacetylene.

2. Results and discussion

The reaction between diamines (1,2-ethanediamine **2**, 1,3-propanediamine **4**, 1,4-butanediamine), 1,1-bis(methylthio)-2-nitroethene, and diaroylacetylene in aqueous EtOH leads to the formation of pyrrolo[2,3-*a*]-fused-1,3-diazaheterocycles in excellent yields (Scheme 1).

The structures of compounds **3a–d**, **5a–d**, and **6a–b** (Fig. 1) were deduced from their elemental analysis, IR, and high-field ¹H, ¹³C NMR spectra. The mass spectrum of **5b** displayed the molecular ion peak at *m/z* 405, which is in agreement with the proposed structure. The IR spectrum of this compound showed absorption bands due to the OH and NH stretching frequency at 3338 and 3040 cm^{−1}.

Absorption bands at 1653 and 1603 cm^{−1} are due to the C=O and NC=C groups. The ¹H NMR spectrum of **5b** showed five multiplets for CH₂ groups because these protons are diastereotopic (δ =1.87–1.90, 2.05–2.09, 2.83–2.88, 3.42–3.46, and 3.51–3.56 ppm), two sharp singlets for the two methyl groups (δ =2.27 and 2.36 ppm), four doublets for the aromatic moieties in the aromatic region of the spectrum (δ =7.07–7.79 ppm) and three singlets for CH, NH and OH groups (δ =8.13, 8.55 and 8.92 ppm). The most important difference between ¹H NMR spectrum of compounds **3**, **5**, and **6** is due to the chemical shift of their OH group. For example, compound **3a** can not orient for an intramolecular hydrogen bonding and thus OH appears as a broad bond at 1.59 ppm

while for **5b**, intramolecular hydrogen bond causes that OH group resonances at down field (8.92 ppm). The ¹H decoupled ¹³C NMR spectrum of **5b** showed 19 distinct resonances in agreement with the suggested structure.

Finally, the structures of **5b** and **6b** were further confirmed by X-ray crystallographic analysis (Fig. 1).

Although we have not established the mechanism of reaction experimentally, a possible explanation is proposed in Scheme 2.

Two isomers *Z* and *E* for all products were expected, but when the different 1,*n*-diamines were applied in the reaction, only one of the two possible isomers (*E* or *Z*) was obtained stereospecifically for each of them. The ¹H and ¹³C NMR, and IR spectral data of the crude product clearly indicated the structures of all these products.

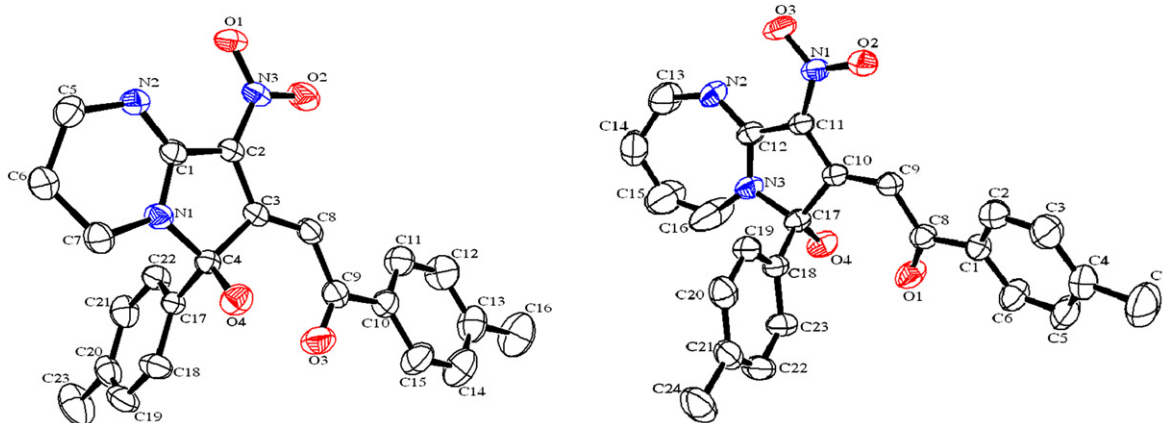
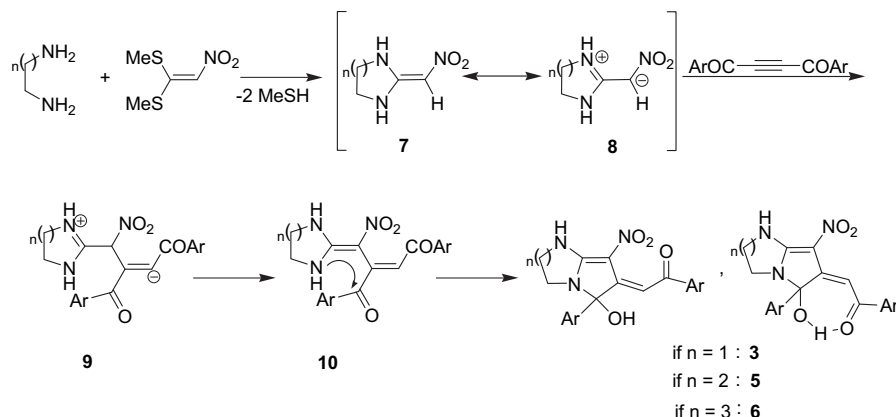


Fig. 1. The molecular structure of compound **5b** and **6b**.



Scheme 2. A plausible mechanism for the formation of products **3a–d**, **5a–d** and **6a,b**.

3. Conclusion

In summary, we have discovered a novel, mild, and straightforward procedure for the synthesis of a new class of substituted *N*-heterocyclic derivatives from the three-component reaction between nitroenamines, derived from the addition of various diamines to *l,l*-bis(methylthio)-2-nitroethene, and diacylacetylene, in aqueous media. Depending on the ring size of the cyclic nitroenamines, various new pyrrolo[1,2-*a*]imidazoles, pyrrolo[1,2-*a*]pyrimidines, and pyrrolo[1,2-*a*][1,3]diazepines have been prepared. Good yields of the products, the ready availability of the starting materials and the reaction's simplicity of the process recommend this as a useful method.

4. Experimental

4.1. General

The diamines, and *l,l*-bis(methylthio)-2-nitroethene were obtained from Merck (Germany) and Fluka (Switzerland) and were used without further purification. Diacylacetylene was prepared according to published procedures.^{26,27} Melting points were measured on an Electrothermal 9100 apparatus. Elemental analyses for C, H, and N were performed using a Heraeus CHN–O–Rapid analyzer. Mass spectra were recorded on a FINNIGAN-MATT 8430 mass spectrometer operating at an ionization potential of 70 eV. ¹H and ¹³C NMR spectra were measured (CDCl₃ solution) with a Bruker DRX-500 AVANCE spectrometer at 500.13 and 125.8 MHz, respectively. IR spectra were recorded on a Shimadzu IR-460 spectrometer, absorbencies are reported in cm^{−1}.

4.2. General synthesis procedure: (for example **5b**)

A solution of *l,l*-bis(methylthio)-2-nitroethene (0.162 g, 1 mmol) and 1,3-propanediamine (0.074 g, 1 mmol) in ethanol (5 mL) was magnetically stirred for 4 h at reflux. Then a solution of 1,4-bis(4-methylphenyl)-2-butyne-1,4-dione (0.26 g, 1 mmol) in ethanol (3 mL) was added dropwise at rt and the mixture was stirred for 2 h. The solvent was removed under reduced pressure, and the residue was purified by silica gel (Merck 230–240 mesh) column chromatography using hexane–EtOAc (5:1).

4.2.1. 2-[5-Hydroxy-7-nitro-5-phenyl-2,3-dihydro-1H-pyrrolo[1,2-*a*]imidazol-6(5H)-yliden]-1-phenyl-1-ethanone (3a**).** Yellow powder, mp=120–124 °C (decomp.), 0.327 g, yield: 90%. IR (KBr) ($\nu_{\max}$, cm^{−1}): 3345 (OH), 3048 (NH), 1649 (NC=C), 1623 (C=O), 1600, 1577 and 1525 (Ph), 1553 and 1394 (C–NO₂), 1263 (C–N), 1171 (C–O). Anal. calcd for C₂₀H₁₇N₃O₄ (363.37): C, 66.11; H, 4.72; N,

11.56%. Found: C, 66.17; H, 4.63; N, 11.32%. MS (EI, 70 eV): *m/z* (%)= 357 (4), 343 (58), 331 (12), 313 (72), 297 (50), 284 (138), 226 (10), 105 (137), 77 (96), 51 (27). δ_{H} (500.1 MHz, CDCl₃): 1.59 (1H, s, OH), 3.04 (1H, q, ³*J*_{HH}=10.2 Hz, CH₂), 3.79 (1H, td, ²*J*_{HH}=10.2 Hz, ³*J*_{HH}=4.7 Hz, CH₂), 4.04 (1H, td, ²*J*_{HH}=10.2 Hz, ³*J*_{HH}=4.7 Hz, CH₂), 4.18 (1H, q, ³*J*_{HH}=10.2 Hz, CH₂), 7.28–7.35 (2H, m, 2CH of Ph), 7.39 (2H, t, ³*J*=7.9 Hz, 2CH of Ph), 7.49 (2H, d, ³*J*=7.1 Hz, 2CH of Ph), 7.54 (2H, d, ³*J*=7.2 Hz, 2CH of Ph), 7.90 (2H, d, ³*J*=7.9 Hz, 2CH of Ph), 8.06 (1H, s, C=CH), 8.37 (1H, s, NH). δ_{C} (125.7 MHz, CDCl₃): 41.4 (CH₂NH), 48.4 (CH₂N), 91.3 (COH), 108.4 (C=CH), 110.1 (C–NO₂), 125.3 (2CH of Ph), 128.4 (2CH of Ph), 128.5 (2CH of Ph), 128.6 (2CH of Ph), 129.0 (CH of Ph), 132.9 (CH of Ph), 137.71 (C_{ipso}–COH), 138.6 (C_{ipso}–CO), 159.0 (C=CH), 163.5 (NHCN), 191.8 (CO).

4.2.2. 2-[5-Hydroxy-5-(4-methylphenyl)-7-nitro-2,3-dihydro-1H-pyrrolo[1,2-*a*]imidazol-6(5H)-yliden]-1-(4-methylphenyl)-1-ethanone (3b**).** Yellow powder, mp=100–105 °C (decomp.), 0.332 g, yield: 85%. IR (KBr) ($\nu_{\max}$, cm^{−1}): 3353 (OH), 3065 (NH), 1650 (NC=C), 1602 (C=O), 1610, 1567 and 1515 (Ar), 1539 and 1389 (C–NO₂), 1275 (C–N), 1176 (C–O). Anal. calcd for C₂₂H₂₁N₃O₄ (391.42): C, 67.51; H, 5.41; N, 10.74%. Found: C, 67.48; H, 5.47; N, 10.68%. MS (EI, 70 eV): *m/z* (%)=391 (M⁺, 4), 387 (27), 328 (41), 312 (73), 234 (59), 178 (63), 149 (58), 91 (74), 69 (100), 43 (93). δ_{H} (500.1 MHz, CDCl₃): 1.59 (1H, s, OH), 2.28 (3H, s, CH₃), 2.37 (3H, s, CH₃), 3.05 (1H, q, ³*J*_{HH}=10.1 Hz, CH₂), 3.79 (1H, td, ²*J*_{HH}=10.2 Hz, ³*J*_{HH}=4.7 Hz, CH₂), 4.04 (1H, td, ²*J*_{HH}=10.2 Hz, ³*J*_{HH}=4.6 Hz, CH₂), 3.79 (1H, q, ³*J*_{HH}=10.1 Hz, CH₂), 7.11 (2H, d, ³*J*_{HH}=8.0 Hz, 2CH of Ar), 7.19 (2H, d, ³*J*_{HH}=8.1 Hz, 2CH of Ar), 7.39 (2H, d, ³*J*_{HH}=8.1 Hz, 2CH of Ar), 7.82 (2H, d, ³*J*_{HH}=8.0 Hz, CH of Ar), 8.04 (1H, s, C=CH), 8.42 (1H, s, NH). δ_{C} (125.7 MHz, CDCl₃): 21.0 (CH₃), 21.5 (CH₃), 41.3 (CH₂NH), 48.3 (CH₂N), 91.4 (COH), 108.6 (C=CH), 110.8 (C–NO₂), 125.3 (2CH of Ar), 128.9 (2CH of Ar), 129.1 (2CH of Ar), 129.1 (2CH of Ar), 134.8 (C_{ipso}–COH), 136.0 (C_{ipso}–Me), 138.8 (C_{ipso}–CO), 143.7 (C_{ipso}–Me), 158.6 (C=CH), 163.4 (NHCN), 191.9 (CO).

4.2.3. 2-[5-Hydroxy-2-methyl-7-nitro-5-phenyl-7-nitro-2,3-dihydro-1H-pyrrolo[1,2-*a*]imidazol-6(5H)-yliden]-1-phenyl-1-ethanone (3c**).** Yellow powder, mp=110–114 °C (decomp.), 0.347 g, yield: 92%. IR (KBr) ($\nu_{\max}$, cm^{−1}): 3271 (OH), 3062 (NH), 1657 (NC=C), 1619 (C=O), 1595, 1576 and 1522 (Ph), 1545 and 1382 (C–NO₂), 1266 (C–N), 1176 (C–O). Anal. calcd for C₂₁H₁₉N₃O₄ (377.40): C, 66.83; H, 5.07; N, 11.13%. Found: C, 66.75; H, 5.11; N, 11.17%. MS (EI, 70 eV): *m/z* (%)=377 (M⁺, 6), 344 (22), 297 (7), 234 (6), 105 (31), 91 (24), 77 (31), 57 (35), 43 (100). δ_{H} (500.1 MHz, CDCl₃): 1.59 (1H, s, OH), 1.45 (3H, d, ³*J*_{HH}=6.1 Hz, CH₃), 3.44–3.52 (1H, m, CH), 3.71 (1H, t, ³*J*_{HH}=10.4 Hz, CH₂), 4.08 (1H, t, ³*J*_{HH}=9.7 Hz, CH₂), 7.26–7.53 (10H, m, 10CH of Ph), 8.03 (1H, s, C=CH), 8.46 (1H, s, NH). δ_{C} (125.7 MHz, CDCl₃): 18.8 (CH₃), 48.0 (CH), 52.4 (CH₂N), 92.2 (COH), 108.3 (C=CH), 111.5 (C–NO₂), 125.3 (2CH of Ph), 128.4 (2CH of Ph), 128.5 (2CH of Ph),

128.6 (2CH of Ph), 128.9 (1CH of Ph), 132.7 (1CH of Ph), 137.4 ($C_{ipso}-COH$), 138.5 ($C_{ipso}-CO$), 159.5 ($C=CH$), 163.5 (NHCN), 191.7 (CO).

4.2.4. 2-[5-Hydroxy-2-methyl-5-(4-methylphenyl)-7-nitro-2,3-dihydro-1H-pyrrolo[1,2-a]imidazol-6(5H)-yliden]-1-(4-methylphenyl)-1-ethanone (3d). Yellow powder, mp=100–105 °C (decomp.), 0.352 g, yield: 87%. IR (KBr) (ν_{max} , cm^{-1}): 3340 (OH), 3053 (NH), 1653 (NC=C), 1604 (C=O), 1590, 1566 and 1520 (Ar), 1563 and 1348 (C–NO₂), 1285 (C–N), 1177 (C–O). Anal. calcd for C₂₃H₂₃N₃O₄ (405.45): C, 68.13; H, 5.72; N, 10.36%. Found: C, 68.22; H, 5.59; N, 10.34%. MS (EI, 70 eV): m/z (%)=405 (M⁺, 9), 387 (8), 359 (32), 286 (13), 257 (17), 178 (31), 149 (55), 119 (32), 69 (100), 57 (89), 43 (84). δ_H (500.1 MHz, CDCl₃): 1.45 (3H, d, $^3J_{HH}=6.1$ Hz, CH₃), 1.53 (1H, s, OH), 2.29 (3H, s, CH₃), 2.36 (3H, s, CH₃), 3.47–3.52 (1H, m, CH), 3.70 (1H, t, $^3J_{HH}=10.4$ Hz, CH₂), 4.06 (1H, t, $^3J_{HH}=9.7$ Hz, CH₂), 7.12 (2H, d, $^3J_{HH}=8.2$ Hz, 2CH of Ar), 7.18 (2H, d, $^3J_{HH}=8.1$ Hz, 2CH of Ar), 7.41 (2H, d, $^3J_{HH}=7.9$ Hz, 2CH of Ar), 7.81 (2H, d, $^3J_{HH}=8.1$ Hz, CH of Ar), 8.01 (1H, s, C=CH), 8.50 (1H, s, NH). δ_C (125.7 MHz, CDCl₃): 18.7 (CH₃), 21.0 (CH₃), 21.6 (CH₃), 52.4 (CH), 55.6 (CH₂N), 92.3 (COH), 108.0 (C=CH), 114.0 (C–NO₂), 125.3 (2CH of Ar), 128.9 (2CH of Ar), 129.0 (2CH of Ar), 129.1 (2CH of Ar), 134.5 ($C_{ipso}-COH$), 136.0 ($C_{ipso}-Me$), 138.8 ($C_{ipso}-CO$), 143.6 ($C_{ipso}-Me$), 159.1 (C=CH), 163.5 (NHCN), 191.2 (CO).

4.2.5. 2-[6-Hydroxy-8-nitro-6-phenyl-1,2,3,4-tetrahydropyrrolo[1,2-a]pyrimidin-7(6H)-yliden]-1-phenyl-1-ethanone (5a). Yellow powder, mp=130–134 °C (decomp.), 0.332 g, yield: 88%. IR (KBr) (ν_{max} , cm^{-1}): 3301 (OH), 3085 (NH), 1665 (NC=C), 1615 (C=O), 1595, 1586 and 1521 (Ph), 1565 and 1391 (C–NO₂), 1286 (C–N), 1192 (C–O). Anal. calcd for C₂₁H₁₉N₃O₄ (377.40): C, 66.83; H, 5.07; N, 11.13%. Found: C, 66.76; H, 5.00; N, 11.15%. MS (EI, 70 eV): m/z (%)=377 (M⁺, 37), 331 (100), 286 (9), 256 (21), 105 (69), 91 (9), 77 (57), 57 (17), 43 (14). δ_H (500.1 MHz, CDCl₃): 1.87–1.90 (1H, m, CH₂), 2.06–2.09 (1H, m, CH₂), 2.81–2.86 (1H, m, CH₂), 3.43–3.45 (1H, m, CH₂), 3.53–3.56 (2H, m, CH₂), 7.24–7.31 (2H, m, 2CH of Ph), 7.36 (2H, t, $^3J=7.6$ Hz, 2CH of Ph), 7.46 (2H, d, $^3J=7.5$ Hz, 2CH of Ph), 7.51 (2H, d, $^3J=7.5$ Hz, 2CH of Ph), 7.86 (2H, d, $^3J=7.6$ Hz, 2CH of Ph), 8.14 (1H, s, C=CH), 8.51 (1H, s, NH), 8.93 (1H, s, OH). δ_C (125.7 MHz, CDCl₃): 19.6 (CH₂), 36.2 (CH₂NH), 38.3 (CH₂N), 93.1 (COH), 107.6 (C=CH), 111.8 (C–NO₂), 125.6 (2CH of Ph), 128.1 (2CH of Ph), 128.3 (2CH of Ph), 128.6 (2CH of Ph), 128.9 (1CH of Ph), 132.6 (1CH of Ph), 138.3 ($C_{ipso}-COH$), 138.68 ($C_{ipso}-CO$), 154.4 (C=CH), 154.7 (NHCN), 192.2 (CO).

4.2.6. 2-[6-Hydroxy-6-(4-methylphenyl)-8-nitro-1,2,3,4-tetrahydropyrrolo[1,2-a]pyrimidin-7(6H)-yliden]-1-(4-methylphenyl)-1-ethanone (5b). Yellow powder, mp=120–124 °C (decomp.), 0.385 g, yield: 90%. IR (KBr) (ν_{max} , cm^{-1}): 3338 (OH), 3040 (NH), 1653 (NC=C), 1603 (C=O), 1593, 1575 and 1519 (Ph), 1561 and 1383 (C–NO₂), 1285 (C–N), 1178 (C–O). Anal. calcd for C₂₃H₂₃N₃O₄ (405.45): C, 68.13; H, 5.72; N, 10.36%. Found: C, 68.02; H, 5.74; N, 10.33%. MS (EI, 70 eV): m/z (%)=405 (M⁺, 28), 359 (83), 286 (6), 270 (17), 194 (6), 149 (8), 119 (53), 84 (89), 69 (18), 49 (100). δ_H (500.1 MHz, CDCl₃): 1.87–1.90 (1H, m, CH₂), 2.05–2.09 (1H, m, CH₂), 2.27 (3H, s, CH₃), 2.36 (3H, s, CH₃), 2.83–2.88 (1H, m, CH₂), 3.42–3.46 (1H, m, CH₂), 3.51–3.56 (2H, m, CH₂), 7.07 (2H, d, $^3J_{HH}=8.05$ Hz, 2CH of Ar), 7.17 (2H, d, $^3J_{HH}=8.1$ Hz, 2CH of Ar), 7.38 (2H, d, $^3J_{HH}=8.1$ Hz, 2CH of Ar), 7.79 (2H, d, $^3J_{HH}=8.2$ Hz, CH of Ar), 8.13 (1H, s, C=CH), 8.55 (1H, s, NH), 8.92 (1H, s, OH). δ_C (125.7 MHz, CDCl₃): 19.7 (CH₂), 21.0 (CH₃), 21.6 (CH₃), 36.1 (CH₂NH), 38.2 (CH₂N), 93.1 (COH), 107.8 (C=CH), 112.2 (C–NO₂), 125.5 (2CH of Ar), 128.8 (2CH of Ar), 128 (2CH of Ar), 129.0 (2CH of Ar), 135.5 ($C_{ipso}-COH$), 136.1 ($C_{ipso}-Me$), 138.6 ($C_{ipso}-CO$), 143.5 ($C_{ipso}-Me$), 154.3 (C=CH), 154.4 (NHCN), 191.8 (CO). Crystal data for **5b** C₂₃H₂₃N₃O₄ (CCDC 778304): $M_W=405.5$, triclinic, space group $P-1$, $a=5.9788(4)$ Å, $b=10.8688(7)$ Å, $c=17.1068(12)$ Å, $\alpha=77.991(1)^\circ$, $\beta=88.607(1)^\circ$, $\gamma=78.278(1)^\circ$, $V=1064.57(12)$ Å³, $Z=2$, $D_c=1.265$ mg/m³, $F(000)=273$, crystal dimension $0.12 \times 0.20 \times 0.48$ mm, radiation, Mo K α ($\lambda=0.71073$ Å), $1.96 \leq 2\theta \leq 25.20$, intensity data were collected

at 295(2) K with a Bruker APEX area-detector diffractometer, and employing $\omega/2\theta$ scanning technique, in the range of $-6 \leq h \leq 7$, $-12 \leq k \leq 12$, $-20 \leq l \leq 20$; the structure was solved by a direct method, all non-hydrogen atoms were positioned and anisotropic thermal parameters refined from 2635 observed reflections with R (into)=0.0768 by a full-matrix least-squares technique converged to $R=0.0509$ and $R_{w}=0.1524$ [$I > 2\sigma(I)$]. Complete crystallographic data (excluding structural factors) have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication number CCDC 778304. Copies of the data can be obtained, free of charge, on application to CCDC, 12 Union Road, Cambridge CB2 1EZ, UK [fax: +44(0) 1223 336033 or e-mail: deposit@ccdc.com.ac.uk].

4.2.7. 2-[6-Hydroxy-3,3-dimethyl-8-nitro-6-phenyl-1,2,3,4-tetrahydropyrrolo[1,2-a]pyrimidin-7(6H)-yliden]-1-phenyl-1-ethanone (5c). Yellow powder, mp=220–225 °C (decomp.), 0.364 g, yield: 90%. IR (KBr) (ν_{max} , cm^{-1}): 3315 (OH), 3056 (NH), 1667 (NC=C), 1615 (C=O), 1600, 1577 and 1523 (Ph), 1553 and 1391 (C–NO₂), 1288 (C–N), 1177 (C–O). Anal. calcd for C₂₃H₂₃N₃O₄ (405.451): C, 68.13; H, 5.72; N, 10.36%. Found: C, 68.17; H, 5.69; N, 10.43%. MS (EI, 70 eV): m/z (%)=405 (M⁺, 6), 387 (8), 362 (67), 344 (65), 330 (24), 270 (18), 161 (17), 91 (100), 57 (21), 43 (25). δ_H (500.1 MHz, CDCl₃): 0.82 (3H, s, CH₃), 1.09 (3H, s, CH₃), 2.54 (1H, d, $^3J_{HH}=12.3$ Hz, CH₂), 3.14 (2H, AB_q, $^3J_{HH}=12.4$ Hz, CH₂), 3.20 (1H, d, $^3J_{HH}=12.3$ Hz, CH₂), 7.26–7.31 (2H, m, 2CH of Ph), 7.37 (2H, t, $^3J=7.8$ Hz, 2CH of Ph), 7.47 (2H, d, $^3J=7.5$ Hz, 2CH of Ph), 7.52 (2H, d, $^3J=7.5$ Hz, 2CH of Ph), 7.86 (2H, d, $^3J=7.8$ Hz, 2CH of Ph), 8.15 (1H, s, C=CH), 8.40 (1H, s, NH), 8.87 (1H, s, OH). δ_C (125.7 MHz, CDCl₃): 24.0 (CH₃), 24.3 (CH₃), 27.6 (Me₂C), 47.6 (CH₂NH), 50.0 (CH₂N), 92.9 (COH), 107.8 (C=CH), 111.7 (C–NO₂), 125.7 (2CH of Ph), 128.0 (2CH of Ph), 128.3 (2CH of Ph), 128.6 (2CH of Ph), 128.8 (CH of Ph), 132.6 (CH of Ph), 138.5 ($C_{ipso}-COH$), 138.7 ($C_{ipso}-CO$), 153.6 (C=CH), 154.9 (NHCN), 192.1 (CO).

4.2.8. 2-[6-Hydroxy-3,3-dimethyl-6-(4-methylphenyl)-8-nitro-1,2,3,4-tetrahydropyrrolo[1,2-a]pyrimidin-7(6H)-yliden]-1-(4-methylphenyl)-1-ethanone (5d). Yellow powder, mp=180–184 °C (decomp.), 0.364 g, yield: 84%. IR (KBr) (ν_{max} , cm^{-1}): 3296 (OH), 3028 (NH), 1658 (NC=C), 1606 (C=O), 1594, 1579 and 1534 (Ph), 1563 and 1344 (C–NO₂), 1276 (C–N), 1176 (C–O). Anal. calcd for C₂₅H₂₇N₃O₄ (433.50): C, 69.27; H, 6.28; N, 9.69%. Found: C, 69.33; H, 6.21; N, 9.62%. MS (EI, 70 eV): m/z (%)=433 (M⁺, 9), 387 (28), 293 (9), 236 (5), 119 (27), 99 (17), 85 (46), 71 (67), 57 (100), 43 (66). δ_H (500.1 MHz, CDCl₃): 0.82 (3H, s, CH₃), 1.08 (3H, s, CH₃), 2.26 (3H, s, CH₃), 2.35 (3H, s, CH₃), 2.54 (1H, d, $^3J_{HH}=12.7$ Hz, CH₂), 3.08 (1H, d, $^3J_{HH}=13.30$ Hz, CH₂), 3.18 (2H, d, $^3J_{HH}=12.6$ Hz, CH₂), 7.07 (2H, d, $^3J_{HH}=8.0$ Hz, 2CH of Ar), 7.16 (2H, d, $^3J_{HH}=8.1$ Hz, 2CH of Ar), 7.39 (2H, d, $^3J_{HH}=8.1$ Hz, 2CH of Ar), 7.78 (2H, d, $^3J_{HH}=8.0$ Hz, CH of Ar), 8.14 (1H, s, C=CH), 8.45 (1H, s, NH), 8.89 (1H, s, OH). δ_C (125.7 MHz, CDCl₃): 21.0 (CH₃), 21.6 (CH₃), 24.0 (CH₃), 24.3 (CH₃), 27.6 (Me₂C), 47.6 (CH₂NH), 50.0 (CH₂N), 93.0 (COH), 108.0 (C=CH), 111.6 (C–NO₂), 125.6 (2CH of Ar), 128.7 (2CH of Ar), 128.8 (2CH of Ar), 129.0 (2CH of Ar), 135.6 ($C_{ipso}-COH$), 136.1 ($C_{ipso}-Me$), 138.6 ($C_{ipso}-CO$), 143.5 ($C_{ipso}-Me$), 153.5 (C=CH), 154.6 (NHCN), 191.7 (CO).

4.2.9. 2-[7-Hydroxy-9-nitro-7-phenyl-2,3,4,5-tetrahydropyrrolo[1,2-a][1,3]diazepin-8(7H)-yliden]-1-phenyl-1-ethanone (6a). Yellow powder, mp=200–205 °C (decomp.), 0.352 g, yield: 90%. IR (KBr) (ν_{max} , cm^{-1}): 3263 (OH), 3051 (NH), 1645 (NC=C), 1612 (C=O), 1604, 1572 and 1515 (Ph), 1564 and 1360 (C–NO₂), 1286 (C–N), 1197 (C–O). Anal. calcd for C₂₂H₂₁N₃O₄ (391.42): C, 67.51; H, 5.41; N, 10.74%. Found: C, 67.36; H, 5.44; N, 10.62%. MS (EI, 70 eV): m/z (%)=391 (M⁺, 55), 345 (100), 286 (23), 268 (35), 119 (22), 105 (99), 91 (16), 77 (30), 55 (24), 41 (9). δ_H (500.1 MHz, CDCl₃): 1.62–1.72 (1H, m, CH₂), 1.82–1.94 (2H, m, CH₂), 1.98–2.09 (1H, m, CH₂), 3.11–3.15 (1H, m, CH₂), 3.58–3.65 (3H, m, CH₂), 7.27–7.31 (2H, m, 2CH of Ph), 7.36 (2H, t, $^3J=7.7$ Hz, 2CH of Ph), 7.47 (2H, d, $^3J=7.7$ Hz, 2CH of Ph),

7.52 (2H, d, $^3J=7.3$ Hz, 2CH of Ph), 7.84 (2H, d, $^3J=7.3$ Hz, 2CH of Ph), 8.13 (1H, s, C=CH), 8.71 (1H, s, NH), 9.98 (1H, s, OH). δ_C (125.7 MHz, $CDCl_3$): 26.0 (CH_2), 27.0 (CH_2), 43.0 (CH_2NH), 44.2 (CH_2N), 93.6 (COH), 107.7 (C=CH), 111.5 (C–NO₂), 125.8 (2CH of Ph), 128.0 (2CH of Ph), 128.3 (2CH of Ph), 128.6 (2CH of Ph), 128.8 (CH of Ph), 132.6 (CH of Ph), 138.7 (C_{ipso} –COH), 138.9 (C_{ipso} –CO), 154.7 (C=CH), 160.0 (NHCN), 192.3 (CO).

4.2.10. 2-[7-Hydroxy-7-(4-methylphenyl)-9-nitro-2,3,4,5-tetrahydropyrrolo[1,2-a][1,3]diazepin-8-(7H)-yliden]-1-(4-methylphenyl)-1-ethanone (6b). Yellow powder, mp=200–205 °C (decomp.), 0.398 g, yield: 95%. IR (KBr) (ν_{max} , cm^{-1}): 3335 (OH), 3052 (NH), 1648 (NC=C), 1602 (C=O), 1600, 1564 and 1515 (Ph), 1558 and 1381 (C–NO₂), 1286 (C–N), 1179 (C–O). Anal. calcd for $C_{24}H_{25}N_3O_4$ (419.48): C, 68.72; H, 6.01; N, 10.02%. Found: C, 68.53; H, 5.99; N, 10.08%. MS (EI, 70 eV): m/z (%)=419 (M^+ , 22), 387 (28), 373 (39), 310 (46), 236 (29), 91 (71), 57 (96), 43 (100). δ_H (500.1 MHz, $CDCl_3$): 1.63–1.72 (1H, m, CH_2), 1.85–1.94 (2H, m, CH_2), 2.01–2.07 (1H, m, CH_2), 2.26 (3H, s, CH_3), 2.35 (3H, s, CH_3), 3.10–3.14 (1H, m, CH_2), 3.56–3.62 (3H, m, CH_2), 7.06 (2H, d, $^3J_{HH}=7.7$ Hz, 2CH of Ar), 7.16 (2H, d, $^3J_{HH}=7.7$ Hz, 2CH of Ar), 7.39 (2H, d, $^3J_{HH}=7.8$ Hz, 2CH of Ar), 7.77 (2H, d, $^3J_{HH}=7.8$ Hz, CH of Ar), 8.12 (1H, s, C=CH), 8.75 (1H, s, NH), 9.98 (1H, s, OH). δ_C (125.7 MHz, $CDCl_3$): 21.0 (CH_3), 21.56 (CH_3), 26.0 (CH_2), 27.0 (CH_2), 43.0 (CH_2NH), 44.1 (CH_2N), 93.6 (COH), 107.8 (C=CH), 112.9 (C–NO₂), 125.7 (2CH of Ar), 128.7 (2CH of Ar), 128.8 (2CH of Ar), 129.0 (2CH of Ar), 136.0 (C_{ipso} –COH), 136.1 (C_{ipso} –Me), 138.5 (C_{ipso} –CO), 143.5 (C_{ipso} –Me), 154.5 (C=CH), 159.8 (NHCN), 191.9 (CO). Crystal data for **6b** $C_{24}H_{25}N_3O_4$ (CCDC 778303): $M_W=419.44$, triclinic, space group $P-1$, $a=6.4600$ (3) Å, $b=10.4517$ (4) Å, $c=15.7074$ (7) Å, $\alpha=90.0550$ (10), $\beta=95.1650$ (10), $\gamma=90.9930$ (10), $V=1056.06$ (8) Å³, $Z=2$, $D_c=1.306$ mg/m³, $F(000)=436$, crystal dimension $0.28 \times 0.23 \times 0.15$ mm, radiation, Mo K α ($\lambda=0.71073$ Å), $1.30 \leq 2\theta \leq 25.20$, intensity data were collected at 295 (2) K with a Bruker APEX area-detector diffractometer, and employing $\omega/2\theta$ scanning technique, in the range of $-7 \leq h \leq 7$, $-12 \leq k \leq 12$, $-18 \leq l \leq 18$; the structure was solved by a direct method, all non-hydrogen atoms were positioned and anisotropic thermal parameters refined from 3055 observed reflections with $R(\text{into})=0.0705$ by a full-matrix least-squares technique converged to $R=0.0574$ and $Raw=0.1648$ [$I > 2\sigma(I)$]. Complete crystallographic data (excluding structural factors) have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication number CCDC 778303. Copies of the data can be obtained, free of charge, on application to CCDC, 12 Union Road, Cambridge CB2 1EZ, UK [fax: +44(0) 1223 336033 or e-mail: deposit@ccdc.com.ac.uk].

Supplementary data

Supplementary data associated with this article can be found in online version at [doi:10.1016/j.tet.2010.10.052](https://doi.org/10.1016/j.tet.2010.10.052).

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