Interaction of barbituric acids with *o*-dialkylaminobenzaldehydes

Konstantin A. Krasnov,[a] Viktor G. Kartsev[b] and Victor N. Khrustalev*[c]

[a] *I. I. Mechnikov State Medical Academy, 195067 St. Petersburg, Russian Federation*
[b] *InterBioScreen Ltd., 142432 Chernogolovka, Moscow Region, Russian Federation*
[c] *A. N. Nesmeyanov Institute of Organoelement Compounds, Russian Academy of Sciences, 119991 Moscow, Russian Federation. Fax: +7 495 135 5085; e-mail: vkh@xray.ineos.ac.ru*

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Barbituric or 2-thiobarbituric acids interact with *o*-dialkylaminobenzaldehydes to give 5-*o*-dialkylaminobenzylidene derivatives, which cyclise into 2,4,6-trioxoperhydropyrimidine-5-spiro-3′-(1′,2′,3′,4′-tetrahydroquinolines) under mild conditions; the mechanism of the key stage of a *tert*-amino effect reaction is disclosed on the basis of the XRD analysis of 1,3-dimethyl-5-(2-dimethylamino-4-nitrobenzylidene)barbituric acid.

The chemistry of barbituric acids attracts permanent attention because barbiturates and related pyrimidine derivatives are of importance for biology and medicine. Here, we report a simple approach to a new group of 5,5-spirobarbituric acids.

Although it is believed[1–3] that the interaction of barbituric acid **1a** and related compounds with aromatic aldehydes has been explored in detail, no data on the condensation of acid **1a** with *ortho*-dialkylamino benzaldehydes, such as 2-dimethylamino-4-nitrobenzaldehyde **2a**,† have been reported. A careful treatment of acid **1a** with aldehyde **2a** in aqueous ethanol resulted in a typical Knövenagel product, 5-(2-dimethylamino-4-nitrobenzylidene)barbituric acid **3a**.‡ Furthermore, short heating of 5-arylidenebarbiturate **3a** in acetic acid afforded spirocyclic system **4a** in a high yield.§ Similarly, the condensation of 1,3-dimethylbarbituric acid **1b** with aldehyde **2a** gave Knövenagel product **3b**,¶ which was isomerised into spirobarbiturate **4b**†† (Scheme 1).

The rearrangement of 5-arylidenebarbiturates **3a**,**b** into spirocyclic system derivatives **4a**,**b** can be classified as the *tert*-amino effect.[4] This approach has been generally employed to the synthesis of annelated quinoline derivatives, but no spirocyclic systems have been afforded in this way.[4] Only at a recent time, *tert*-amino effect reactions (T-reactions) were applied to the preparation of spirocyclic systems containing barbituric acid, cyclohexane-1,3-dione or a Meldrum's acid moiety.[5–9]

Typically, the rearrangement of *o*-vinyl-substituted *N*,*N*-dialkylanilines into the corresponding heterocycles required severe conditions.[10,11] In contrast to non-spirocyclic analogues, compounds **4a**,**b** were obtained under surprisingly mild conditions. Kinetic measurements identified that compound **3b** isomerised

† The ^{1}H and ^{13}C NMR spectra were recorded on a Bruker AM spectrometer at 500 and 125 MHz, respectively. Reagents **1a**–**e** were purchased from commercial suppliers. Aldehydes **2a**-**e** were synthesised by following procedures.

2-Dimethylamino-4-nitrobenzaldehyde **2a**. Aqueous dimethylamine 33% (35 ml, 0.25 mol) was added to a solution of 2-chloro-4-nitrobenzaldehyde (18.5 g, 0.1 mol) in DMF (50 ml), and the reaction mixture was stirred under reflux at 50 °C for 2 h. The mixture was diluted with water (100 ml), the precipitate was washed with water and recrystallised from aqueous EtOH to give **2a**. Yield 90%, yellow crystals, mp 132–133 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 3.08 (s, 6H, NMe_2), 6.93 (d, 1H, ArH, *J* 8.6 Hz), 8.14 (d, 1H, ArH, *J* 8.6 Hz), 8.49 (s, 1H, ArH), 9.97 (s, 1H, CHO). Found (%): C, 55.45; H, 5.62; N, 14.18. Calc. for $C_9H_{10}N_2O_3$ (%): C, 55.67; H, 5.19; N, 14.43.

2-Dimethylamino-4-methylbenzaldehyde **2b**. *N*,*N*-Dimethyl-4-methylaniline (13.5 g, 0.1 mol) was added to a solution of $POCl_3$ (23.1 g, 0.15 mol) in DMF (50 ml) and the reaction mixture was heated for 5 h at 95 °C. After cooling, the solution was poured into water (200 ml), neutralised with NH_4OH and extracted with Et_2O (2×50 ml). The combined organics were washed with aqueous AcOH (10%) and water, dried with Na_2SO_4 and concentrated *in vacuo*. Yield 60%, colourless oil. ^{1}H NMR ($CDCl_3$) δ: 2.31 (s, 3H, ArMe), 2.87 (s, 6H, NMe_2), 6.96 (d, 1H, ArH, *J* 8.9 Hz), 7.26 (d, 1H, ArH, *J* 8.9 Hz), 7.56 (s, 1H, ArH), 10.25 (s, 1H, CHO). Found (%): C, 73.14; H, 8.21; N, 8.40. Calc. for $C_{10}H_{13}NO$ (%): C, 73.59; H, 8.03; N, 8.58.

2-Dimethylamino-4,5-dimethylbenzaldehyde **2c** was obtained similarly by formylation of *N*,*N*-dimethyl-4,5-dimethylaniline. Yield 36%, colourless oil. ^{1}H NMR ($CDCl_3$) δ: 2.29 (s, 3H, ArMe), 2.32 (s, 3H, ArMe), 2.85 (s, 6H, NMe_2), 7.32 (s, 1H, ArH), 7.49 (s, 1H, ArH), 10.28 (s, 1H, CHO). Found (%): C, 74.16; H, 8.81; N, 8.03. Calc. for $C_{11}H_{15}NO$ (%): C, 74.54; H, 8.53; N, 7.90.

2-Diethylamino-4-nitrobenzaldehyde **2d**. A mixture of 2-chloro-4-nitrobenzaldehyde (18.5 g, 0.1 mol), diethylamine (8.0 g, 0.11 mol) and K_2CO_3 (15.2 g, 1.1 mol) in DMF (45 ml) was stirred for 3 h at 80–90 °C. The reaction mixture was diluted with water (150 ml), the precipitate was washed with water and recrystallised from aqueous EtOH to give **2d**. Yield 82%, yellow crystals, mp 68–69 °C. ^{1}H NMR ($CDCl_3$) δ: 1.22 (t, 6H, 2Me, *J* 7.2 Hz), 3.43 [q, 4H, $N(CH_2)_2$, *J* 7.2 Hz], 7.01 (d, 1H, ArH, *J* 8.4 Hz), 8.20 (d, 1H, ArH, *J* 8.4 Hz), 8.58 (s, 1H, ArH), 10.01 (s, 1H, CHO). Found (%): C, 59.11; H, 6.56; N, 12.33. Calc. for $C_{11}H_{14}N_2O_3$ (%): C, 59.45; H, 6.35; N, 12.60.

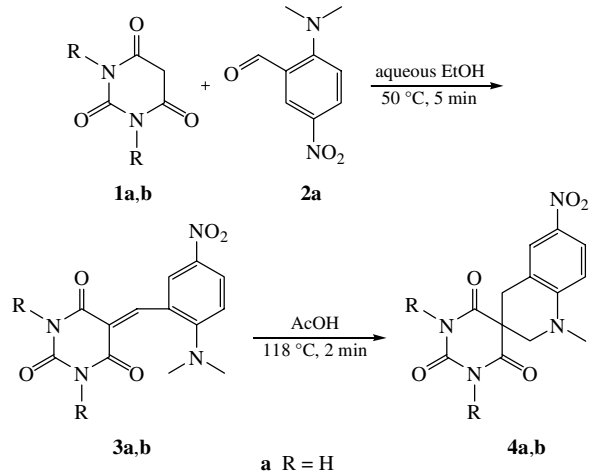
*2-(*N*-methyl-*N*-benzylamino)-4-nitrobenzaldehyde* **2e** was obtained similarly, using *N*-methyl-*N*-benzylamine. Yield 73%, yellow crystals, mp 135–136 °C. ^{1}H NMR ($CDCl_3$) δ: 3.04 (s, 3H, NMe), 4.63 (s, 2H, NCH_2), 6.97 (d, 1H, ArH, *J* 8.9 Hz), 7.15–7.36 (m, 5H, Ph), 8.19 (d, 1H, ArH, *J* 8.9 Hz), 8.62 (s, 1H, ArH), 10.05 (s, 1H, CHO). Found (%): C, 66.17; H, 5.00; N, 10.03. Calc. for $C_{11}H_{14}N_2O_3$ (%): C, 66.66; H, 5.22; N, 10.36.

‡ *5-(2-Dimethylamino-4-nitrobenzylidene)barbituric acid* **3a**. A solution of **2a** (1.94 g, 10 mmol) in 25 ml EtOH was added to a solution of **1a** (1.28 g, 10 mmol) in 50 ml of H_2O–EtOH (1:1) at 60 °C, and the reaction mixture was stirred for 5 min. The precipitate was separated, washed with aqueous EtOH and air dried. Yield 94%, red crystals, mp 290 °C (decomp.). ^{1}H NMR ([$^2H_6$]DMSO) δ: 3.06 (s, 6H, NMe_2), 7.07 (d, 1H, ArH, *J* 7.0 Hz), 8.12 (d, 1H, ArH, *J* 7.0 Hz), 8.15 (s, 1H, ArH), 8.64 (s, 1H, =CH), 11.21 (s, 1H, NH), 11.31 (s, 1H, NH). ^{13}C NMR ([$^2H_6$]DMSO) δ: 43.73 (2Me), 115.45 (CH), 117.57 (*C*=CH), 120.71 (CH), 126.46 (CH), 128.80 (*C*CH=), 137.27 (CNO_2), 150.24 [C(2)O], 151.21 (*C*NMe_2), 157.91 (CH=), 163.28, 161.52 [C(4)O, C(6)O]. Found (%): C, 51.11; H, 4.13; N, 18.25. Calc. for $C_{13}H_{12}N_4O_5$ (%): C, 51.32; H, 3.98; N, 18.41.

§ *2,4,6-Trioxoperhydropyrimidine-5-spiro-3′-(1′-methyl-6′-nitro-1′,2′,3′,4′-tetrahydroquinoline)* **4a**. A suspension of **3a** (0.3 g, 1 mmol) in AcOH (20 ml) was heated for 2–3 min until complete dissolution. After cooling, the mixture was diluted with water (30 ml), the precipitate was washed with water and air dried. Yield 84%, yellow crystals, mp > 316 °C (decomp.). ^{1}H NMR ([$^2H_6$]DMSO) δ: 3.12 (s, 3H, NMe), 3.18 (s, 2H, CH_2), 3.68 (s, 2H, NCH_2), 6.64 (d, 1H, ArH, *J* 9.5 Hz), 7.87 (s, 1H, ArH), 7.93 (d, 1H, ArH, *J* 9.5 Hz), 11.17 (s, 2H, 2NH). ^{13}C NMR ([$^2H_6$]DMSO) δ: 33.07 (Me), 38.51 (CH_2N), 46.90 (*C*CO), 53.78 (CH_2N), 109.27 (CH), 119.45 [C(5)], 123.83 (CH), 123.98 (CH), 135.60 (CNO_2), 150.19 [C(2)O], 150.31 (*C*NMe_2), 170.60 [C(4)O + C(6)O]. MS, *m*/*z* (%): 304 (100) $[M]^+$, 287 (61), 274 (11), 257 (13), 188 (22), 171 (10), 160 (11), 143 (19), 131 (24). Found (%): C, 51.20; H, 4.03; N, 18.29. Calc. for $C_{13}H_{12}N_4O_5$ (%): C, 51.32; H, 3.98; N, 18.41.

¶ *1,3-Dimethyl-5-(2-dimethylamino-4-nitrobenzylidene)barbituric acid* **3b** was obtained from **1b** and **2a**. Yield 91%, red crystals, mp 233–234 °C. ^{1}H NMR ($CDCl_3$) δ: 3.03 (s, 6H, NMe_2), 3.37 (s, 3H, NMe), 3.42 (s, 3H, NMe), 6.94 (d, 1H, ArH, *J* 9.2 Hz), 8.17 (dd, 1H, ArH, J_1 9.5 Hz, J_2 2.5 Hz), 8.44 (s, 1H, =CH), 8.70 (d, 1H, =CH, *J* 2.5 Hz). Found (%): C, 54.07; H, 4.94; N, 16.70. Calc. for $C_{15}H_{16}N_4O_5$ (%): C, 54.22; H, 4.85; N, 16.86.

†† *1,3-Dimethyl-2,4,6-trioxoperhydropyrimidine-5-spiro-3′-(1′-methyl-6′-nitro-1′,2′,3′,4′-tetrahydroquinoline)* **4b** obtained from **3b**. Yield 85%, yellow crystals, mp 244–245 °C. ^{1}H NMR ($CDCl_3$) δ: 3.12 (s, 3H, $N_{piperid}$Me), 3.24 (s, 3H, NMe), 3.29 (s, 2H, CH_2Ar), 3.30 (s, 3H, NMe), 3.69 (s, 2H, CH_2N), 6.64 (d, 1H, ArH, *J* 9.5 Hz), 7.91 (d, 1H, ArH, *J* 2.3 Hz), 8.07 (dd, 1H, ArH, J_1 9.5 Hz, J_2 2.3 Hz). Found (%): C, 54.13; H, 4.91; N, 16.75. Calc. for $C_{15}H_{16}N_4O_5$ (%): C, 54.22; H, 4.85; N, 16.86.



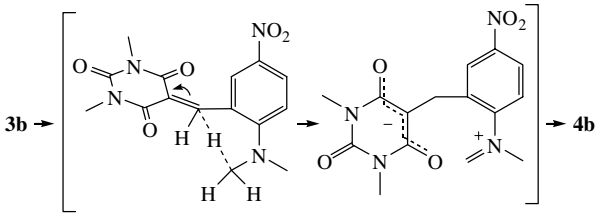
1a,**b** **2a** **3a**,**b** **4a**,**b**

a R = H
b R = Me

Scheme 1

into **4b** at the rate constants $k = 2.3\times10^{-5}$ s^{-1} at 60 °C, 1.6×10^{-4} s^{-1} at 80 °C, and 1.2×10^{-3} s^{-1} at 100 °C; the activation energy of the process can be estimated as $E_a = 24.5\pm0.5$ kcal mol^{-1}.‡‡

All reactions of these types are two-step processes, first involving hydrogen detachment from the α position of the *t*-amino function followed by the cyclization of the dipolar intermediate.[4] Hydrogen transfer should be considered as the key stage of the *tert*-amino effect; however, the mechanism of this stage is still unclear. To get an insight into this mechanism, the structure of 5-arylidenebarbiturate **3b** was studied by X-ray diffraction analysis.§§



5 **6**

Scheme 2

Note that the hydrogen atom H(17A) of one of the two methyl groups of the dimethylamino substituent in compound **3b** is located at a distance of 2.34(2) Å from the vinylic carbon atom C(9) [the C(17)...C(9) distance is 2.867(3) Å, the C(17)–H(17A)···C(9) angle is 113(2)°] (Figure 1). For comparison, the sum of van der Waals radii for carbon and hydrogen

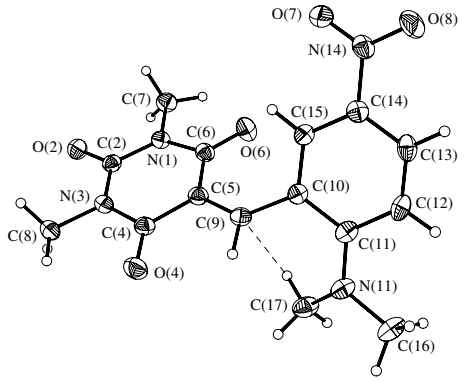
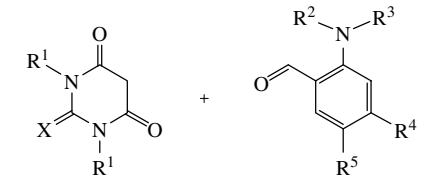


Figure 1 Molecular structure of **3b**.

atoms is 2.95 Å, and that for two carbon atoms is 3.50 Å. The (N)C–H···C=C contact, as well as the spatial orientation of the methyl group, presumes the presence of very strong C–H···π(C=C) intramolecular interaction in the crystal, which cannot be explained solely by packing effects. Note that there are no steric hindrances for the free rotation of the dimethylamino group around the N–C_{aryl} bond in the crystal. Moreover, due to the C–H···π(C=C) intramolecular interaction, the nitrogen atom N(11) of this group adopts a slightly pyramidalised configuration (the sum of the bond angles at the nitrogen atom is 356.5°), and the carbon atom C(17) deviates from the benzene plane by 0.732 Å [meanwhile, the deviation of another methyl carbon atom C(16) from the same plane is only 0.096 Å]. The interactions of this type are well known.[12–16] In the case of compound **3b**, the involvement of the methyl group into the C–H···π(C=C) interaction is attributed to the strong polarization of the C(5)=C(9) bond. Note that the respective double bond exhibits rather strong Lewis acidity: in particular, 1,3-dimethyl-5-arylidenebarbiturates react with amines and other nucleophiles forming stable zwitterionic adducts.[17]

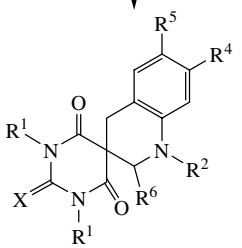
The strong intramolecular C–H···π(C=C) interaction in 5-arylidenebarbiturate **3b** may be considered as a contributory factor for the subsequent hydrogen migration that proceeds *via* transition state **5** to give intermediate **6**. On the other hand, the



1a X = O, R^1 = H
1b X = O, R^1 = Me
1c X = O, R^1 = Ph
1d X = S, R^1 = Me
1e X = S, R^1 = Ph

2b $R^2 = R^3 = R^5$ = Me, R^4 = H
2c $R^2 = R^3 = R^4 = R^5$ = Me
2d $R^2 = R^3$ = Et, R^4 = H, $R^5 = NO_2$
2e R^2 = Me, $R^3 = CH_2Ph$, R^4 = H, $R^5 = NO_2$

60 °C, 10–15 min | aqueous EtOH



4c X = O, $R^1 = R^4 = R^6$ = H, $R^2 = R^5$ = Me
4d X = O, $R^1 = R^2 = R^5$ = Me, $R^4 = R^6$ = H
4e X = O, R^1 = Ph, $R^2 = R^5$ = Me, $R^4 = R^6$ = H
4f X = S, $R^1 = R^2 = R^5$ = Me, $R^4 = R^6$ = H
4g X = S, R^1 = Ph, $R^2 = R^5$ = Me, $R^4 = R^6$ = H
4h X = O, $R^1 = R^2 = R^4 = R^5$ = Me, R^6 = H
4i X = O, $R^1 = R^4$ = H, R^2 = Et, $R^5 = NO_2$, R^6 = Me
4j X = O, $R^1 = R^4$ = H, R^2 = Me, $R^5 = NO_2$, R^6 = Ph

Scheme 3

‡‡ *Kinetic measurements.* Compound **3b** (10 mg, 0.03 mmol) was dissolved in [$^2H_6$]DMSO (0.6 ml) in an NMR tube and thermostated at the given temperatures for the reaction time. At known intervals, ^{1}H NMR spectra were recorded. Concentrations of starting compound **3b** and product **4b** were calculated as average values of integrals of aromatic CH signals. The maximum integration error is 2%.

§§ *Crystal data for* **3b**: $C_{15}H_{16}N_4O_5$, M = 332.32, triclinic, space group $P\bar{1}$, at T = 120 K: a = 8.208(5), b = 8.741(5) and c = 11.540(7) Å, α = = 102.827(11)°, β = 102.443(11)°, γ = 104.090(10)°, V = 750.5(8) Å^3, Z = 2, d_{calc} = 1.470 g cm^{-3}, R_1 = 0.0484 for 2210 independent reflections with $I > 2\sigma(I)$, wR_2 = 0.1218 for all 3254 independent reflections.

6944 reflections were measured on a Bruker SMART 1000 CCD diffractometer [λ(MoKα)-radiation, graphite monochromator, φ and ω scan mode, θ_{max} = 27°]. The structure was determined by direct methods and by full-matrix least squares refinement with anisotropic thermal parameters for non-hydrogen atoms. The hydrogen atoms were objectively localised in the difference Fourier syntheses and refined isotropically.

Atomic coordinates, bond lengths, bond angles and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre (CCDC). These data can be obtained free of charge *via* www.ccdc.cam.uk/conts/retrieving.html (or from the CCDC, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44 1223 336 033; or deposit@ccdc.cam.ac.uk). Any request to the CCDC for data should quote the full literature citation and CCDC reference number 278524. For details, see 'Notice to Authors', *Mendeleev Commun.*, Issue 1, 2006.

cyclization of compound **3b** and its analogues is favoured by the stabilization of zwitter-ionic system **6** through the effective delocalization of the negative charge over the atoms of the β-dicarbonyl pentad. Taking all these aspects into consideration, the mechanism of hydrogen migration in 5-arylidenebarbiturate **3b** may be described as the intramolecular uptake of a hydrid ion by a Lewis acceptor.

A high rate of the *tert*-amino effect cyclization was proved by the examination of the reactivity of 2-dimethylamino-4-methylbenzaldehyde **2b**† in these reactions. The condensation of acid **1a** with aldehyde **2b** afforded spirocyclic derivative **4c**¶¶ without stopping at the Knövenagel stage, even at a room temperature. The formation of the Knövenagel intermediate manifests itself only by appearance of a deep red colour of the reaction mixture. Kinetic measurements showed that the rate of this two-step process was limited by the first stage. We have restricted ourselves by estimation that the rate of the rearrangement of 5-(2-dimethylamino-4-methylbenzylidene)barbiturate at 20 °C in DMSO is three orders of magnitude (or more) higher than that in the case of its 4-nitro analogue **3a**.

1,3-Dimethylbarbituric **1b** and 1,3-diphenylbarbituric **1c** acids, as well as their 2-thio analogues **1d**,**e**, interact with aldehyde **2b** to afford spirocyclic products **4d**–**g**.¶¶ 2-Dimethylamino-4,5-dimethylbenzaldehyde **2c**† was found to react similarly to its analogue **2b**: the condensation of **2c** with acid **1a** yielded spirocyclic product **4h**.¶¶ The interaction of 2-diethylamino-4-nitro **2d** or 2-benzylmethylamino-4-nitro **2e** benzaldehydes† with acid **1a** proceeds to give 5-spirobarbiturates **4i**,**j**.¶¶

These data show that aldehydes **2b**–**e**, in contrast to 2-dimethylamino-4-nitrobenzaldehyde **2a**, do not form stable Knövenagel adducts with barbituric acids. It seems evident that the considerably higher affinity of 5-arylidenebarbiturates derived from aldehydes **2b**–**e** towards cyclization is due to an increase in the electron density at the alkylamino group and to the stabilization of cationic segment in the zwitter-ionic intermediate.

In conclusion, the study of T-reactions of barbituric acid derivatives clarified the mechanism of hydrogen migration in the *tert*-amino effect and enabled a simple method for the preparation of new heterocyclic systems containing the pyrimidine-5-spiro-3′-quinoline skeleton.

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¶¶ *General procedure*. An ethanolic solution of aldehyde **2b**–**e** (10 mmol) was added to a stirred solution of barbituric or 2-thiobarbituric acid derivative **1a**–**e** (10 mmol) in aqueous EtOH (70%) at 60–70 °C, and the mixture was heated at 60 °C for 10–15 min. Then the mixture was cooled and the precipitate was purified by crystallization from EtOH.

2,4,6-Trioxoperhydropyrimidine-5-spiro-3′-(1′,6′-dimethyl-1′,2′,3′,4′-tetrahydroquinoline) **4c**. Yield 91%, colourless crystals, mp 286–287 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 2.21 (s, 3H, ArMe), 2.87 (s, 3H, NMe), 3.05 (s, 2H, ArCH_2), 3.35 (s, 2H, NCH_2), 6.50 (d, 1H, ArH, *J* 7.3 Hz), 6.80 (s, 1H, ArH), 6.81 (d, 1H, ArH, *J* 7.3 Hz), 11.12 (s, 2H, 2NH). ^{13}C NMR ([$^2H_6$]DMSO) δ: 19.97 (*Me*Ar), 31.06 (NMe), 38.67 (*C*H_2Ar), 50.09 (*C*CO), 56.38 (NCH_2), 111.47 (CH), 121.52 (C), 125.41 (C), 126.81 (CH), 128.58 (CH), 143.47 (C$_{arom}$N), 171.13 [C(4)O, C(6)O], 150.36 [C(2)O]. MS, *m*/*z* (%): 273 (100) [M]$^+$, 258 (43), 201 (25), 186 (14). Found (%): C, 61.41; H, 5.66; N, 15.29. Calc. for $C_{14}H_{15}N_3O_3$ (%): C, 61.53; H, 5.53; N, 15.38.

1,3-Dimethyl-2,4,6-trioxoperhydropyrimidine-5-spiro-3′-(1′,6′-dimethyl-1′,2′,3′,4′-tetrahydroquinoline) **4d**. Yield 79%, colourless crystals, mp 151–152 °C. ^{1}H NMR ($CDCl_3$) δ: 6.92 (d, 1H, ArH, *J* 7.3 Hz), 6.85 (s, 1H, ArH), 6.59 (d, 1H, ArH, *J* 7.3 Hz), 3.40 (s, 2H, NCH_2), 3.30 (s, 6H, 2NMe), 3.22 (s, 2H, ArCH_2), 2.92 (s, 3H, NMe), 2.25 (s, 3H, ArMe). ^{13}C NMR ($CDCl_3$) δ: 169.53 [C(4)O, C(6)O], 151.36 [C(2)O], 142.74 (C$_{arom}$N), 128.98 (CH), 127.84 (CH), 127.32 (C), 120.52 (C), 112.04 (CH), 58.11 (CH_2N) 50.95 (*C*CO), 39.47 (*C*H_2Ar), 32.82 (*Me*NAr), 29.05 (2MeN), 20.36 (*Me*Ar). Found (%): C, 63.59; H, 6.54; N, 13.80. Calc. for $C_{16}H_{19}N_3O_3$ (%): C, 63.77; H, 6.36; N, 13.94.

1,3-Diphenyl-2,4,6-trioxoperhydropyrimidine-5-spiro-3′-(1′,6′-dimethyl-1′,2′,3′,4′-tetrahydroquinoline) **4e**. Yield 82%, colourless crystals, mp 253–254 C. ^{1}H NMR ($CDCl_3$) δ: 2.22 (s, 3H, ArMe), 2.97 (s, 3H, NMe), 3.29 (s, 2H, ArCH_2), 3.73 (s, 2H, NCH_2), 6.53 (d, 1H, ArH, *J* 8.0 Hz), 6.80 (d, 1H, ArH, *J* 8.0 Hz), 6.89 (s, 1H, ArH), 7.29–7.47 (m, 10H, 2Ph). ^{13}C NMR ($CDCl_3$) δ: 20.32 (*Me*Ar), 32.36 (MeN), 39.53 (*C*H_2Ar), 52.37 (*C*CO), 58.23 (CH_2N), 112.14 (CH), 120.26 (C), 127.56 (CH), 127.90 (CH), 128.20 (C), 128.28 (4CH), 129.02 (2CH), 129.30 (4CH), 134.37 (2C), 142.64 (C$_{arom}$N), 150.63 [C(2)O], 168.94 [C(4)O, C(6)O]. Found (%): C, 72.98; H, 5.73; N, 9.56. Calc. for $C_{26}H_{23}N_3O_3$ (%): C, 73.40; H, 5.45; N, 9.88.

1,3-Dimethyl-2-thioxo-4,6-dioxoperhydropyrimidine-5-spiro-3′-(1′,6′-dimethyl-1′,2′,3′,4′-tetrahydroquinoline) **4f**. Yield 75%, colourless crystals, mp 192–193 °C. ^{1}H NMR ($CDCl_3$) δ: 2.26 (s, 3H, ArMe), 2.92 (s, 3H, ArN*Me*), 3.29 (s, 2H, ArCH_2), 3.42 (s, 2H, NCH_2), 3.66 (s, 6H, 2NMe), 6.62 (d, 1H, ArH, *J* 8.2 Hz), 6.89 (s, 1H, ArH), 6.93 (d, 1H, ArH, *J* 8.2 Hz). ^{13}C NMR ($CDCl_3$) δ: 20.39 (*Me*Ar), 32.22 (*Me*NAr), 35.95 (2MeN), 39.50 (*C*H_2Ar), 52.11 (*C*CO), 57.74 (CH_2N), 112.14 (CH), 120.42 (C), 127.50 (C), 127.88 (CH), 129.07 (CH), 142.68 (C$_{arom}$N), 168.04 (2CO), 180.60 (CS). Found (%): C, 54.27; H, 4.99; N, 16.84; S, 10.06. Calc. for $C_{16}H_{19}N_3O_2S$ (%): C, 54.22; H, 4.85; N, 16.86; S, 10.10.

1,3-Diphenyl-2-thioxo-4,6-dioxoperhydropyrimidine-5-spiro-3′-(1′,6′-dimethyl-1′,2′,3′,4′-tetrahydroquinoline) **4g**. Yield 84%, colourless crystals, mp 241–242 °C. ^{1}H NMR ($CDCl_3$) δ: 2.25 (s, 3H, Ar*Me*), 3.05 (s, 3H, NMe), 3.46 (s, 2H, ArCH_2), 3.74 (s, 2H, NCH_2), 6.60 (d, 1H, ArH, *J* 7.2 Hz), 6.91 (d, 1H, ArH, *J* 7.2 Hz), 6.96 (s, 1H, ArH), 7.16 (m, 4H, 2Ph), 7.41–7.48 (m, 6H, 2Ph). Found (%): C, 70.45; H, 5.48; N, 9.33; S, 7.14. Calc. for $C_{26}H_{23}N_3O_2S$ (%): C, 70.72; H, 5.25; N, 9.52; S, 7.26.

1,3-Dimethyl-2,4,6-trioxoperhydropyrimidine-5-spiro-3′-(1′,5′,6′-trimethyl-1′,2′,3′,4′-tetrahydroquinoline) **4h**. Yield 76%, colourless crystals, mp 143–144 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 2.08 (s, 3H, Ar*Me*), 2.12 (s, 3H, Ar*Me*), 2.85 (s, 3H, NMe), 3.10 (s, 2H, CCH_2), 3.34 (s, 2H, NCH_2), 6.40 (s, 1H, ArH), 6.72 (s, 1H, ArH), 11.06 (s, 2H, 2NH). ^{13}C NMR ([$^2H_6$]DMSO) δ: 18.55 (*Me*Ar), 19.84 (*Me*Ar), 32.21 (*Me*NAr), 38.87 (*C*H_2Ar), 50.32 (*C*CO), 56.90 (CH_2N), 112.13 (CH), 118.68 (C), 126.51 (C), 130.79 (CH), 135.92 (C), 143.15 (C$_{arom}$N), 150.44 [C(2)O], 170.94 [C(4)O, C(6)O]. Found (%): C, 64.91; H, 6.86; N, 13.22. Calc. for $C_{17}H_{21}N_3O_3$ (%): C, 64.74; H, 6.71; N, 13.32.

2,4,6-Trioxoperhydropyrimidine-5-spiro-3′-(1′-ethyl-2′-methyl-6′-nitro-1′,2′,3′,4′-tetrahydroquinoline) **4i**. Yield 70%, yellow crystals, mp 244–245 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 1.02 (d, 3H, CH*Me*, *J* 6.6 Hz), 1.11 (t, 3H, CH_2*Me*, *J* 7.5 Hz), 2.88 and 3.49 (AB-d, 2H, ArCH_2, *J* 17.5 Hz), 3.33 and 3.60 (AB-m, 2H, NCH_2), 4.01 (q, 1H, NCH, *J* 6.6 Hz), 6.68 (d, 1H, ArH, *J* 9.3 Hz), 7.89 (d, 1H, ArH, *J* 9.3 Hz), 7.94 (s, 1H, ArH), 11.08 (s, 1H, NH), 11.25 (s, 1H, NH). Found (%): C, 54.57; H, 4.97; N, 16.79. Calc. for $C_{15}H_{16}N_4O_5$ (%): C, 54.22; H, 4.85; N, 16.86.

2,4,6-Trioxoperhydropyrimidine-5-spiro-3′-(1′-methyl-2′-phenyl-6′-nitro-1′,2′,3′,4′-tetrahydroquinoline) **4j**. Yield 87%, yellow crystals, mp 224–225 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 2.90 (s, 3H, NMe), 3.36 and 3.13 (AB-d, 2H, NCH_2, *J* 17.5 Hz), 5.13 (s, 1H, NCH), 6.65 (m, 1H, ArH), 7.01 (m, 2H, Ph), 7.24 (m, 3H, Ph), 7.92 (d, 1H, ArH, *J* 5.0 Hz), 8.04 (m, 1H, ArH), 11.12 (s, 2H, 2NH). Found (%): C, 59.88; H, 4.30; N, 14.79. Calc. for $C_{19}H_{16}N_4O_5$ (%): C, 60.00; H, 4.24; N, 14.73.