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Nucleophilic [3 + 3] addition of dimedone *N*-alkylimines to pyrrolo[1,2-*a*]quinoxaline-1,2,4-triones

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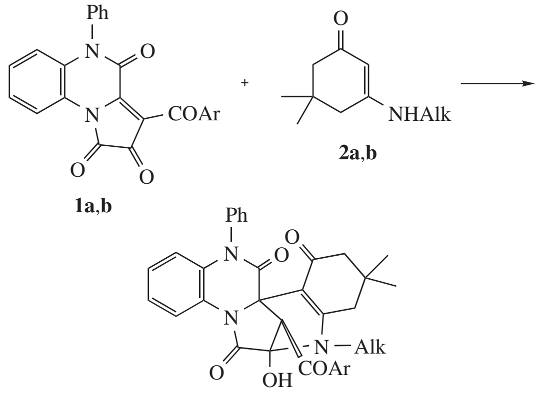
1-Alkylamino-5,5-dimethyl-1-cyclohexen-3-ones react with pyrrolo[1,2-*a*]quinoxaline-1,2,4-triones to form substituted 3,10,13-triazapentacyclo[10.7.1.$0^{1,10}$.$0^{4,9}$.$0^{14,19}$]icosa-4,6,8,14(19)-tetraene-2,11,18-triones.

Polycyclic fused 4-acyl-1*H*-pyrrole-2,3-diones undergo various recyclisation and heterocyclisation reactions with binucleophilic reagents[1–3] to form polycarbonyl-substituted aza heterocycles, which are difficult to prepare.

The use of these binucleophilic reagents as the enamine forms of dimedone *N*-alkylimines in reactions with quinoxalino fused 1*H*-pyrrole-2,3-diones has opened a new unexpected direction of their heterocyclisation. We found that the interaction of 3-aroyl-5-phenyl-1,2,4,5-tetrahydropyrrolo[1,2-*a*]quinoxaline-1,2,4-triones **1a**,**b** with 1-alkylamino-5,5-dimethyl-1-cyclohexen-3-ones **2a**,**b** on short-term heating (15–25 min) in dry benzene gave rise to bridged pentacyclic 13-alkyl-12-hydroxy-20-aroyl-16,16-dimethyl-3-phenyl-3,10,13-triazapentacyclo[10.7.1.$0^{1,10}$.$0^{4,9}$.$0^{14,19}$]icosa-4,6,8,14(19)-tetraene-2,11,18-triones **3a**,**b** in good yields.[†] The structure of compound **3a** was confirmed by X-ray analysis.

Most likely, at the initial stage of the interaction, an activated β-CH group of enamines **2a**,**b** attaches to the C(3a) atom of pyrroloquinoxalinetriones **1a**,**b**, as described previously for the reactions of these compounds with mono-[4] and binucleophiles.[3,5] This step is followed by an intramolecular attack of the *sec*-amino group of enamines onto the C(2) atom of pyrroloquinoxalinetriones to result in tetrahydropyridine ring closing and formation of bridged compounds **3a**,**b**. It is of interest that the toluene and dichloroethane solutions of these compounds are colourless at 0–20 °C, but they become dark violet on heating and lighten on cooling. The colour of solutions intensifies as the temperature increases. This is most probably a result of the reversibility[4] of



1a,**b**

2a,**b**

3a,**b**

a Ar = 4-BrC_6H_4, Alk = $CH_2CH{=}CH_2$
b Ar = 4-$MeOC_6H_4$, Alk = CH_2Ph

Scheme 1

enamine addition to pyrroloquinoxalinetriones **1a**,**b**, whose solutions are dark violet.

The described interaction can be considered as a new regioselective way to the hitherto inaccessible functionalised bridged heterocycle system of the triazapentacycloicosatetraene type and as the first example of enamine nucleophilic [3 + 3] addition to polycyclic fused 1*H*-pyrrole-2,3-diones.

The molecular structure of **3a** is shown in Figure 1.[‡] The bond lengths and bond angles are usual. The tetrahydropyridine ring including the N(3) atom has an ‘envelope’ configuration with the fold along the C(1)···C(3) line (a dihedral angle of 65.1°) and a *p*-bromobenzoyl substitutient occupies a pseudo-equatorial position. The dimethylcyclohexane ring has also the ‘envelope’ configuration with the fold along the C(14)···C(16) line towards the N(2) atom plane (a dihedral angle of 45.7°). The pyrazine ring has a weakly distorted ‘boat’ configuration, which is characterised by displacements of N(1) and N(2) atoms from the plane of other four C atoms (0.21 and 0.52 Å, respectively) and the dihedral angle is equal to 34.3°. In a crystal, the molecules of **3a** are linked by the strong intermolecular H-bonds O(2)–H(2)···O(1) [O(2)···O(1) 2.648 Å, H(2)···O(1) 2.146 Å, the angle O(2)–H(2)–O(1) is 119.5°] thus forming a group along a spiral axis, which is parallel to the *b* axis of the crystal cell, and presents an endless chain.

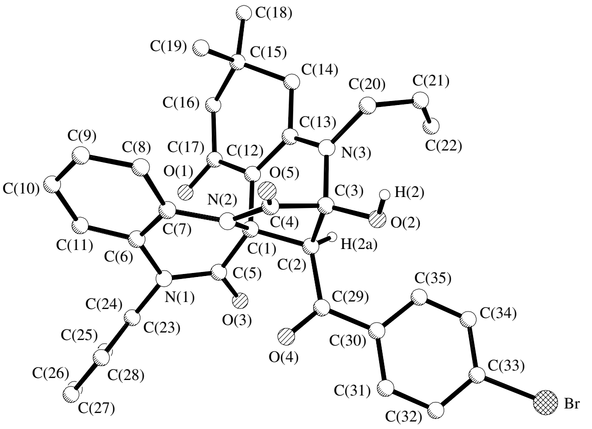


Figure 1 Molecular structure of compound **3a**.

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[†] *A typical experimental procedure*. A solution of enamine **2** (1 mmol) in dry benzene (10 ml) was added dropwise to a solution of pyrroloquinoxalinetrione **1** (1 mmol) in the above solvent (20 ml). The reaction mixture was heated at 80 °C for 25 min and then allowed to cool. The resulted precipitate was filtered off and recrystallised from ethyl acetate to give a crystal product.

13-Allyl-20-(4-bromobenzoyl)-12-hydroxy-16,16-dimethyl-3-phenyl-3,10,13-triazapentacyclo[10.7.1.0^{1,10}.0^{4,9}.0^{14,19}]icosa-4,6,8,14(19)-tetraene-2,11,18-trione **3a**: yield 73%; mp 217–220 °C. ^{1}H NMR (400 MHz, [$^2H_6$]DMSO) δ: 0.82 (s, 3H, Me), 1.03 (s, 3H, Me), 1.96, 2.08 [dd, 2H, C(15)H_2, *J* 15.9 Hz], 2.42, 2.59 [dd, 2H, C(17)H_2, *J* 16.6 Hz], 4.25 (m, 2H, C*H*$_2$CH=CH$_2$), 4.75 [s, 1H, C(20)H], 5.25 (d, 1H, *cis*-CH in CH$_2$CH=C*H*$_2$, *J* 9.8 Hz), 5.28 (d, 1H, *trans*-CH in CH$_2$CH=C*H*$_2$, *J* 16.1 Hz), 5.88 (m, 1H, CH$_2$C*H*=CH$_2$), 6.26 [d, 1H, C(5)H, *J* 7.7 Hz], 6.98–7.87 [m, 11H, Ph, C_6H_4, C(6)H, C(7)H], 7.93 [d, 1H, C(8)H, *J* 7.8 Hz], 8.53 (s, 1H, OH). IR (Nujol, ν/cm^{-1}): 3120 (w, OH), 1719 [C(11)=O], 1701, 1679 [C(2)=O, C(18)=O, COC$_6$H$_4$Br]. Found (%): C, 64.52; H, 4.66; Br, 12.20; N, 6.41. Calc. for $C_{35}H_{30}BrN_3O_5$ (%): C, 64.42; H, 4.63; Br, 12.24; N, 6.44.

13-Benzyl-12-hydroxy-20-(4-methoxybenzoyl)-16,16-dimethyl-3-phenyl-3,10,13-triazapentacyclo[10.7.1.0^{1,10}.0^{4,9}.0^{14,19}]icosa-4,6,8,14(19)-tetraene-2,11,18-trione **3b**: yield 68%, mp 173–175 °C. ^{1}H NMR (400 MHz, [$^2H_6$]DMSO) δ: 0.77 (s, 3H, Me), 0.94 (s, 3H, Me), 1.96, 2.07 [dd, 2H, C(15)H_2, *J* 16.1 Hz], 2.31, 2.55 [dd, 2H, C(17)H_2, *J* 16.6 Hz], 3.82 (s, 3H, MeO), 4.84 [s, 1H, C(20)H], 4.85, 4.92 (dd, 2H, C*H*$_2$Ph, *J* 17.8 Hz), 6.28 [d, 1H, C(5)H, *J* 8.1 Hz], 6.99–7.88 [m, 16H, 2Ph, C_6H_4, C(6)H, C(7)H], 8.00 [d, 1H, C(8)H, *J* 7.8 Hz], 8.50 (s, 1H, OH). IR (Nujol, ν/cm^{-1}): 3060 (w, OH), 1718 [C(11)=O], 1687, 1654 [C(2)=O, C(18)=O, COC$_6$H$_4$OMe]. Found (%): C, 73.51; H, 5.42; N, 6.40. Calc. for $C_{40}H_{35}N_3O_6$ (%): C, 73.49; H, 5.39; N, 6.43.

[‡] *Crystallographic data for* **3a**: $C_{35}H_{30}BrN_3O_5$, $M = 652.53$, rhombic, space group *Pbca*, $a = 16.563(3)$, $b = 16.872(3)$ and $c = 20.708(4)$ Å, $V = 5786.9(18)$ Å^3, $Z = 8$, $d_{\text{calc}} = 1.498$ g cm^{-3}. Crystallographic data for **3a** were collected on a four-circle automated KM 4 diffractometer (Kuma Diffraction) with graphite-monochromated MoKα radiation using an $\omega/2\theta$ scan mode, $1.97° < \theta < 26.07°$ (5484 reflections). No refinement for absorption was applied ($\mu = 1.471$ mm^{-1}). The structure was solved by a direct statistic method with the subsequent series of calculations of electronic density maps and then refined by LSM-refinement with anisotropic approximation for all non-hydrogen atoms using the SHELX-86[6] and SHELXL-93[7] program packages [$R_1 = 0.0498$, $wR_2 = 0.1192$ on 2303 reflections with $I \geq 2\sigma(I)$ and $R_1 = 0.2272$; $wR_2 = 0.1390$ on all 5484 reflections, GOF = 0.858]. The H-atom positions were calculated from geometrical terms.

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 276038. For details, see ‘Notice to Authors’, *Mendeleev Commun.*, Issue 1, 2005.