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A rapid and facile synthesis of new spiropyrimidines from 5-(2-arylethylidene-2-oxo)-1,3-dimethylpyrimidine-2,4,6-triones

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ABSTRACT

A series of new tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraones have been obtained by reaction of 5-(2-arylethylidene-2-oxo)-1,3-dimethylpyrimidine-2,4,6-triones with ureas. A three-component one-pot procedure to the spiranes synthesis was also developed. One-pot reaction of arylglyoxals, 1,3-dimethylbarbituric acid, and dimethylurea led to imidazolyl-1,3-dimethylbarbituric acids. Mechanisms of studied reactions were discussed.

1. Introduction

It is well-known that enone systems are convenient and readily available synthetic fragments in the preparation of various biologically important heterocycles, especially nitrogen-containing compounds, and also analogues of natural compounds.[1–4] The vinyl and carbonyl groups of α,β-unsaturated ketones form the common system, and the reactions with nucleophilic reagents can proceed either in the position 2 or 4 depending on polar influence of the carbonyl group over the vinyl one.[5]

Earlier, we found that the 1,2-nucleophilic addition to aromatic α,β-unsaturated ketones is typical for reactions with vicinal diamines, the nucleophilicity of which is considerably suppressed.[6,7] At the same time, increase in the π-deficiency of the vinylene bond or utilization of more nucleophilic amino groups leads exclusively to 1,4-addition.[8,9] The mutual influence of the ethylene and carbonyl fragments on an enone reactivity is especially pronounced in cyclic α,β-unsaturated ketones with fixed geometry.[10,11] The condensation pathways for cyclic α,β-unsaturated ketones and their acyclic analogues may differ considerably, this is determined not only by *s-cis*-configuration, but also by the stereochemistry of the cyclic fragment.[12,13]

Moreover, spirocompounds based on barbituric acid show a high hypnotic and sedative activity.[14] Earlier we reported the synthesis of spiropyrolines[15] obtained from 5,6-diamino-1,3-dimethyluracil and α,β-unsaturated ketones, and spirotetrahydropyridines[16] produced from 1,3-dimethylbarbituric acid, chalcones, and NH_4OAc. In addition, the importance of pyrimidines with interesting pharmacological activities has prompted many workers to synthesize a number of pyrimidine derivatives.[17,18]

2. Results and discussions

The targets of our research were 5-(2-arylethylidene-2-oxo)-1,3-dimethylpyrimidine-2,4,6-triones **3a–g** obtained by Knoevenagel reaction of 1,3-dimethylbarbituric acid (**1**) and arylglyoxals **2a–g** (Scheme 1). The reaction was accomplished in glacial acetic acid at room temperature overnight. The structure of products **3a–g** was proved by ^{1}H NMR and ^{13}C NMR spectra and elemental analysis data. The typical characteristic signal in their ^{1}H NMR spectra is a singlet corresponding to the vinylene protons at 8.00–8.50 ppm. In the IR spectra, sharp bands were observed due to the stretching vibration of all carbonyl groups (at 1663, 1676, and 1690 cm^{-1}) and bands of C=C group (at 1630 cm^{-1}).

We also examined the behavior of enones **3a–g** in the reactions with typical 1,4-binucleophiles—diamines **4a**,**b**, and also with ureas **5a–e** (Scheme 2). Heating of the compound **3a** with

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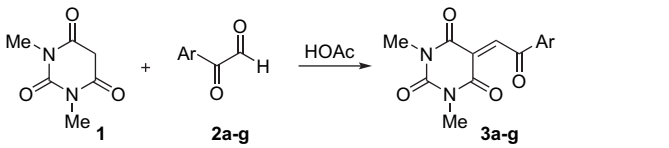


Scheme 1.

o-phenylenediamines **4a**,**b** in methanol at reflux resulted in the well-known quinoxalines **6a**,**b**,[19] and 1,3-dimethylbarbituric acid (**1**) (the last was isolated from the filtrate). The reaction of enones **3a**–**g** with ureas **5a**–**e** led to new spiropyrimidines **7a**–**m** in good yields (63–74%).

The structure of spiropyrimidines **7** was confirmed by ^{1}H NMR spectroscopy. The following signals were detected (DMSO-d_6): proton singlets of the methyl groups of the initial pyrimidine fragment at 2.92–3.33 ppm, multiplets of the aromatic substituents in positions N1 and C4 at 6.96–8.17 ppm, a vinylene singlet proton at 6.12–7.25 ppm, and also broad NH-protons of the spirocycle (compounds **7a**–**e**) at 9.05–9.20 ppm and 11.5–12.0 ppm that refer to amide (N1) and enamine (N3) protons, respectively. There is a signal of spiroatom C-6 at 62.7–63.5 ppm in the ^{13}C NMR spectra of spiroproducts **7a**–**e** (at 65.9–68.2 ppm for *N*-substituted spiranes **7f**–**l**). There are intensive bands of carbonyl groups of spirocycle of compounds **7a**–**l** (at 1750–1765 cm^{-1}), and their acetyl derivatives **8a**–**c** (at 1770 cm^{-1}) in the IR spectra. It is proved the steric tensity of these systems.

The use of arylsubstituted ureas **5b**–**d** in the synthesis hardly influences the yield of spiranes **7f**,**g**,**i**,**j**,**l**,**m**, unlike the similar reactions of chalcones with arylureas, where the yields of pyrimidines decrease.[20] The signal of the proton of the amide group is absent in the ^{1}H NMR spectra of compounds **7f**–**m** and there is a signal of the NH proton of an enamine type in the low field. It proves that at the stage of addition on the carbonyl group, more basic and sterically less hindered amino group participates. The further addition of the amino group on the exocyclic double bond leads to spiropyrimidines **7** in the more thermodynamically stable enamine form.

Spiropyrimidinones **7** were also obtained by a one-pot procedure (for compounds **7a**,**d**,**f**) using the corresponding arylglyoxals **2**, acid **1**, and ureas **5a**,**b**.

The molecular ions of the spiropyrimidines **7** are of maximal intensity in the mass spectra. The main fragmentations include elimination of 1,3-dimethyl-1,3-diazetidin-2,4-dione, an isocyanate radical, an arylnitrile cation, and also regrouping with dimethylurea elimination. As a typical example, Scheme 3 illustrates decomposition processes of compound **7d**.

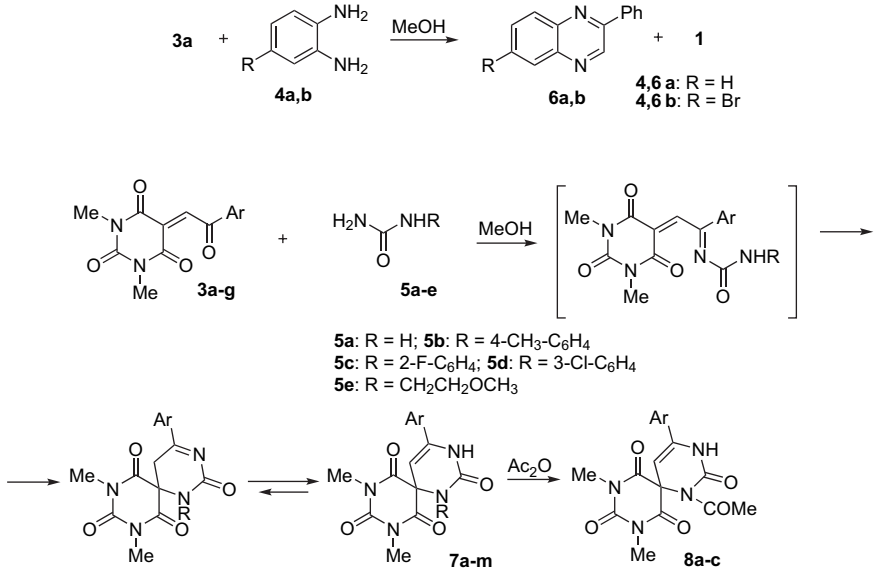
Spirocompounds **7** without substituents at N1 were easily acylated (for pyrimidinones **7a**,**b**,**d**) by acetic anhydride in the indicated position.

Interaction of acid **1**, glyoxals **2c**,**e** and dimethylurea **5f** in methanol with catalytic amounts of glacial acetic acid leads to hydantoins **9c**,**e** (Scheme 4). The ^{1}H NMR spectra (DMSO-d_6) of compounds **9c**,**e** exhibited clear doublets of the substituted aromatic nuclei, singlets of four methyl groups, and a singlet of the methyne proton at 3.70 ppm. There are the signals of C-5 of pyrimidine cycle at 80 ppm and the absence of spiroatom at 63–68 ppm in the ^{13}C NMR spectra of products **9b**,**c**,**e**.

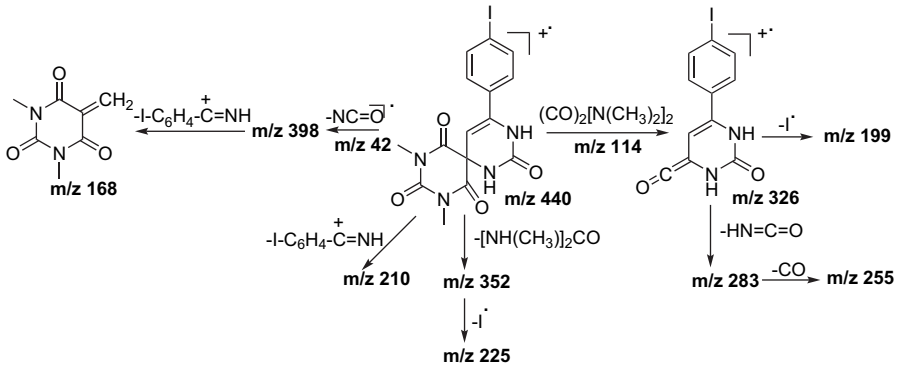
The molecular ions of compound **9c**,**e** are observed in their mass spectra. Fragmentation includes elimination of diazetidine, whereas the elimination of methylisocyanate molecule does not take place.

It is also interesting that compounds **9b**,**e** were synthesized from enones **3b**,**e** and urea **5f** under similar experimental conditions.

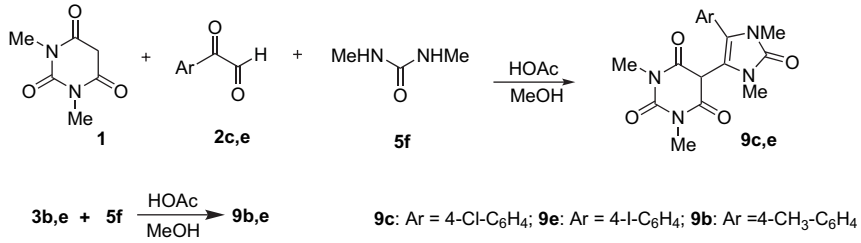
The physicochemical characteristics of product **9e** obtaining by one-pot procedure and from enone **3e** are identical.



Scheme 2.



Scheme 3.



Scheme 4.

The molecular structure of hydantoin **9e** was determined by X-ray diffraction study (Fig. 1).

The five-membered heterocycle is planar, while the six-membered rings are rotated with respect to this plane (the angles C(2)–C(3)–C(5)–N(3) and C(5)–C(6)–C(8)–C(9) are 73.6(2)° and 58.4(3)°, respectively). The molecules are linked into centrosymmetric dimers due to formation of strong intermolecular hydrogen bonds O(3)–H(3O)···O(4)^{i} [*i*: $-x,-y+2,-z+1$] (H···O 1.73 Å, O–H···O 150°). Shortening of the hydroxyl C(4)–O(3) bond up to 1.308(3) Å and elongation of the carbonyl C(7)–O(4) bond up to 1.257(3) Å (mean values are 1.22 and 1.33 Å, respectively[21]) most probably indicate substantial charge transfer due to formation of the H-bond. Also, it is interesting to note short intermolecular I(1)···C(1) contact 3.54 Å (Van der Waals radii sum is 3.86 Å[22]), which very likely can be classified as I···π interaction.

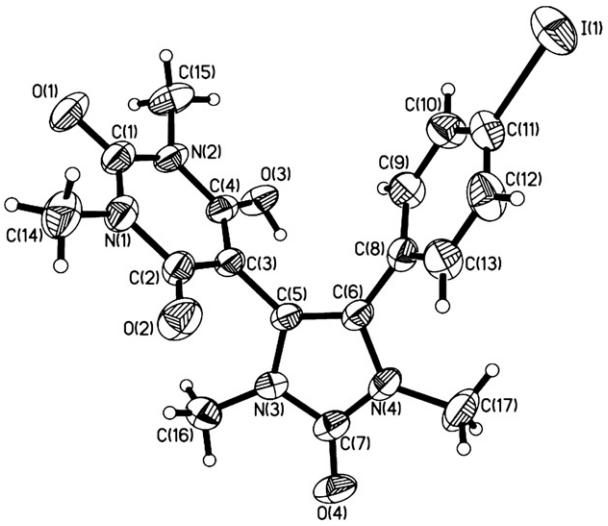


Figure 1.

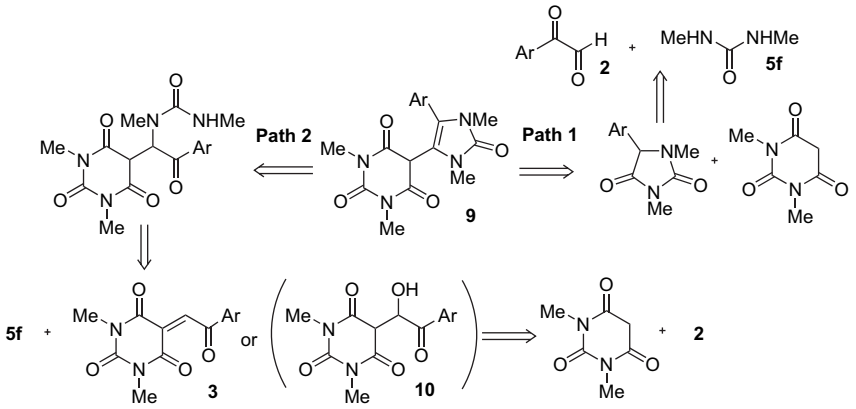
Retrosynthetic analysis (Scheme 5) shows two possibilities for the one-pot synthesis of compounds **9c**,**e**. The first way (path 1) involves the formation of hydantoin from arylglyoxals **2** and dimethylurea (**5f**) and then it condenses with dimethylbarbituric acid (**1**) through Knoevenagel reaction.

The alternative way (path 2) assumes the formation of enone **3** or aldol **10**, which undergoes nucleophilic addition (or substitution) reaction with urea **5f** and further cyclization into products **9**.

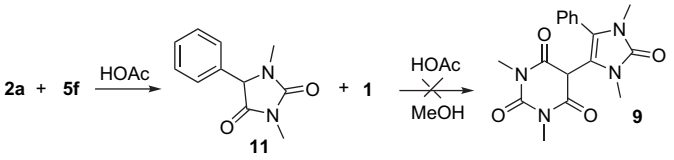
However, hydantoin **11** obtained by well-known method[23] does not react with acid **1** to form compound **9** (Scheme 6). Therefore, the way **2** seems to be more probable. It is also confirmed by the formation of products **9b**,**e** from unsaturated ketones **3b**,**e** and urea **5f** (Scheme 4).

Thus, we propose that hydantoins **9** and quinoxalines **6** form in the reactions of enones **3** with dimethylurea (**5f**) and *o*-phenylenediamines **4** correspondingly via the addition to the π-deficient C=C bond (1,4-addition). In the case of poor nucleophiles (for example, urea) the first step of the reaction is the attack of carbonyl group (1,2-addition) with further formation of spiranes **7**. This argument was confirmed by formation of 2-aminothiazole derivative **13** in the reaction of enone **3a** with thiourea (**12**) (Scheme 7).

At the same time, it is well-accepted in the literature that the 1,4-addition of ureas to α,β-unsaturated ketones is the first reaction step.[23–27] Enones **3** investigated in this work are characterized by a higher π-deficiency of the vinylene bond in comparison with chalcones. This leads to regioselective 1,2- or 1,4-nucleophilic addition to the enones **3**, depending on the nucleophilicity of ureas. Similar results were obtained by Al-Hajjar et al.[24] For the one-pot reaction of ethyl acetoacetate, arylglyoxals, and urea or *N*,*N*-dimethylurea in the presence of Lewis acids, 3,4-dihydropyrimidine derivatives were obtained in the reaction with urea whereas hydantoines were formed in the reaction with *N*,*N*-dimethylurea. A weak nucleophile (unsubstituted urea) reacts in a 1,2-addition fashion with the more active acetyl group, whereas *N*,*N*-dimethylurea reacts with the C=C bond (1,4-addition). Further cyclization with participation of the C=C bond or aroyl group leads to dihydropyrimidines or hydantoines, respectively.



Scheme 5.



Scheme 6.

3. Conclusions

It was shown that the mode of interaction of 5-(2-oxo-2-arylethyliden)-1,3-dimethylbarbituric acids with 1,3- or 1,4-binucleophile is determined by their nucleophilic ability. The reaction may proceed either at the double bond or at the carbonyl group of the exocyclic fragment. Facile and efficient methods of new spiropyrimidinones **7** and imidazolylpyrimidinones **9** synthesis, including a one-pot variant, starting from dimethylbarbituric acid (**1**), arylglyoxals **2**, and appropriately substituted ureas were developed.

4. Experimental

4.1. General

Starting materials were obtained from commercial suppliers. Melting points were determined on a Kofler apparatus. The IR spectra were recorded on a Specord-75 IR spectrometer in KBr. The ^{1}H NMR spectra were recorded at 200 MHz on a Varian Mercury VX-200 spectrometer and ^{13}C NMR spectra were recorded at 100 MHz on a Bruker AM-400 spectrometer with $SiMe_4$ internal reference in DMSO-d_6. Mass spectra were taken on a Hewlett-Packard LC/MSD 1100 series instrument at atmospheric pressure by chemical ionization (positive APCI) mode. Reactions were monitored by TLC (Silufol UV-254) in MeOH/toluene (1:1), toluene/EtOAc (1:1), and toluene/EtOAc (1:4), and visualized under UV light or iodine fume.

Imidazolidine-2,4-dione **11** was synthesized by known procedure.[23]

4.2. Preparation of 5-(2-arylethylidene-2-oxo)-1,3-dimethylpyrimidine-2,4,6-triones (3a–g)

General procedure. A mixture of acid **1** (1.0 mmol) and arylglyoxals **2a–g** (1.0 mmol) in glacial acetic acid (10–12 mL) was stirred at rt overnight. The products **3** were filtered off and washed with water twice.

*4.2.1. 1,3-Dimethyl-5-(2-oxo-2-phenylethylidene)-pyrimidine-2,4,6(1H,3H,5H)-trione (**3a**)*

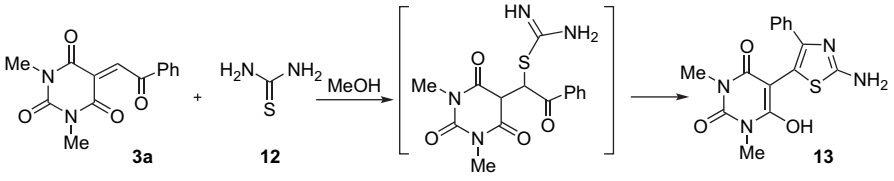
The title compound was obtained as a colorless solid in 81% yield (0.22 g), mp 199–200 °C. [Found: C, 61.67; H, 4.39; N, 10.34. $C_{14}H_{12}N_2O_4$ requires C, 61.76; H, 4.44; N, 10.29%.] ν_{max} (KBr, cm^{-1}) 1630, 1662, 1675, 1690; δ_H (200 MHz, DMSO-d_6) 3.03 (3H, s, *Me*), 3.22 (3H, s, *Me*), 7.48 (1H, m, *p*-Ph), 7.63 (2H, d, *J* 8.0 Hz, *m*-Ph), 7.87 (2H, d, *J* 8.0 Hz, *o*-Ph), 8.15 (1H, s, =C*H*CO); δ_C (100 MHz, DMSO-d_6) 28.5, 29.0, 125.3, 129.1, 129.6, 134.7, 135.4, 151.9, 152.1, 160.6, 161.1, 194.8; MS, *m*/*z* (*I*, %): 272 ($M^{+\bullet}$, 100).

*4.2.2. 1,3-Dimethyl-5-(2-oxo-2-p-tolylethylidene)-pyrimidine-2,4,6-trione (**3b**)*

The title compound was obtained as a colorless solid in 92% yield (0.26 g), mp 213–214 °C. [Found: C, 62.85; H, 4.88; N, 9.71. $C_{15}H_{14}N_2O_4$ requires C, 62.93; H, 4.93; N, 9.79%.] ν_{max} (KBr, cm^{-1}) 1629, 1665, 1678, 1692; δ_H (200 MHz, DMSO-d_6) 2.37 (3H, s, *Me*Ar), 3.03 (3H, s, *Me*), 3.21 (3H, s, *Me*), 7.31 (2H, d, *J* 7.9 Hz, *m*-Ar), 7.75 (2H, d, *J* 7.9 Hz, *o*-Ar), 8.07 (1H, s, =C*H*CO); δ_C (100 MHz, DMSO-d_6) 21.8, 28.4, 29.0, 125.2, 129.2, 130.1, 133.0, 145.3, 151.9, 152.2, 160.6, 161.1, 194.4; MS, *m*/*z* (*I*, %): 286 ($M^{+\bullet}$, 100).

*4.2.3. 5-(2-(4-Chlorophenyl)-2-oxoethylidene)-1,3-dimethylpyrimidine-2,4,6-trione (**3c**)*

The title compound was obtained as a colorless solid in 68% yield (0.205 g), mp 221–222 °C. [Found: C, 54.89; H, 3.68; N, 9.19. $C_{14}H_{11}ClN_2O_4$ requires C, 54.83; H, 3.62; N, 9.13%.] ν_{max} (KBr, cm^{-1}) 1630, 1665, 1677, 1694; δ_H (200 MHz, DMSO-d_6) 3.00 (3H, s, *Me*), 3.20 (3H, s, *Me*), 7.54 (2H, d, *J* 8.4 Hz, *m*-Ar), 7.81 (2H, d, *J* 8.4 Hz, *o*-Ar), 8.11 (1H, s, =C*H*CO); δ_C (100 MHz, DMSO-d_6) 28.4, 29.0, 125.3,



Scheme 7.

129.9, 130.3, 135.0, 141.9, 151.9, 152.1, 160.7, 161.0, 194.8; MS, *m*/*z* (*I*, %): 306 (100), 308 ($M^{+\bullet}$, 33).

4.2.4. 5-(2-(4-Bromophenyl)-2-oxoethylidene)-1,3-dimethylpyrimidine-2,4,6-trione (**3d**)

The title compound was obtained as a colorless solid in 72% yield (0.25 g), mp 230–231 °C. [Found: C, 47.97; H, 3.10; N, 7.86. $C_{14}H_{11}BrN_2O_4$ requires C, 47.89; H, 3.16; N, 7.98%.] ν_{max} (KBr, cm^{-1}) 1628, 1663, 1676, 1690; δ_H (200 MHz, DMSO-d_6) 3.02 (3H, s, *Me*), 3.22 (3H, s, *Me*), 7.50 (2H, d, *J* 8.4 Hz, *m*-Ar), 7.71 (2H, d, *J* 8.4 Hz, *o*-Ar), 8.11 (1H, s, =C*H*CO); δ_C (100 MHz, DMSO-d_6) 28.5, 29.0, 125.2, 129.7, 131.3, 133.0, 134.4, 151.9, 152.2, 160.6, 161.1, 194.7; MS, *m*/*z* (*I*, %): 350 (100), 352 ($M^{+\bullet}$, 98).

4.2.5. 5-(2-(4-Iodophenyl)-2-oxoethylidene)-1,3-dimethylpyrimidine-2,4,6-trione (**3e**)

The title compound was obtained as a colorless solid in 89% yield (0.35 g), mp 228–230 °C. [Found: C, 42.17; H, 2.71; N, 7.08. $C_{14}H_{11}IN_2O_4$ requires C, 42.23; H, 2.78; N, 7.04%.] ν_{max} (KBr, cm^{-1}) 1631, 1664, 1673, 1692; δ_H (200 MHz, DMSO-d_6) 3.03 (3H, s, *Me*), 3.22 (3H, s, *Me*), 7.60 (2H, d, *J* 8.2 Hz, *o*-Ar), 7.89 (2H, d, *J* 8.2 Hz, *m*-Ar), 8.09 (1H, s, =C*H*CO); δ_C (100 MHz, DMSO-d_6) 28.5, 29.0, 125.2, 97.4, 131.5, 135.0, 139.7, 151.9, 152.2, 160.6, 161.1, 194.6; MS, *m*/*z* (*I*, %): 398 ($M^{+\bullet}$, 100).

4.2.6. 1,3-Dimethyl-5-(2-oxo-2-(thiophen-2-yl)ethylidene)-pyrimidine-2,4,6-trione (**3f**)

The title compound was obtained as a colorless solid in 76% yield (0.21 g), mp 228–230 °C. [Found: C, 51.85; H, 3.58; N, 10.11; S, 11.49. $C_{12}H_{10}N_2O_4S$ requires C, 51.79; H, 3.62; N, 10.07; S, 11.52%.] ν_{max} (KBr, cm^{-1}) 1630, 1663, 1675, 1691; δ_H (200 MHz, DMSO-d_6) 3.01 (3H, s, *Me*), 3.21 (3H, s, *Me*), 7.02–7.10 (1H, m, β-thienyl), 7.61 (1H, d, *J* 2.8 Hz, β-thienyl), 7.65 (1H, d, *J* 4.6 Hz, α-thienyl), 8.00 (1H, s, =C*H*CO); δ_C (100 MHz, DMSO-d_6) 28.5, 29.0, 125.4, 129.1, 131.5, 133.0, 138.1, 151.7, 152.1, 160.3, 161.1, 190.0; MS, *m*/*z* (*I*, %): 278 ($M^{+\bullet}$, 100).

4.2.7. 1,3-Dimethyl-5-(2-(4-nitrophenyl)-2-oxoethylidene)-pyrimidine-2,4,6-trione (**3g**)

The title compound was obtained as a colorless solid in 67% yield (0.21 g), mp 209–210 °C. [Found: C, 53.09; H, 3.55; N, 13.22. $C_{14}H_{11}N_3O_6$ requires C, 53.00; H, 3.49; N, 13.245%.] ν_{max} (KBr, cm^{-1}) 1632, 1669, 1675, 1693; δ_H (200 MHz, DMSO-d_6) 3.07 (3H, s, *Me*), 3.26 (3H, s, *Me*), 8.07 (2H, d, *J* 8.0 Hz, *o*-Ar), 8.38 (2H, d, *J* 8.0 Hz, *m*-Ar), 8.50 (1H, s, =C*H*CO); δ_C (100 MHz, DMSO-d_6) 28.6, 29.1, 125.5, 124.3, 130.2, 143.4, 152.3, 152.0, 152.7, 160.6, 161.9, 195.7; MS, *m*/*z* (*I*, %): 317 ($M^{+\bullet}$, 100).

4.3. Preparation of 2-arylquinoxalines 6a,b

A mixture of enone **3a** (1.0 mmol) and *o*-phenylenediamines **4a**,**b** (1.0 mmol) in methanol (8 mL) was heated at reflux for 1 h. The resulting product was filtered off and washed with water and hot methanol.

Compound **6a**. Yellow solid. Yield: 64%, mp 76–77 °C (77–78 °C).[19] Compound **6b**. Yellow solid. Yield: 68%, mp 124–125 °C (124–125 °C).[19]

4.4. Preparation of 4-aryl-8,10-dimethyl-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraones (7a–m)

General procedure A. A mixture of appropriate enones **3a–g** (2.0 mmol) and the corresponding urea derivatives **5a–e** (2.0 mmol) was heated at reflux in methanol (5–7 mL) for 0.5–1.5 h. The resulting products were filtered off, washed with cold methanol or recrystallized.

4.4.1. 8,10-Dimethyl-4-phenyl-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7a**)

The title compound was obtained as a colorless solid in 69% yield (0.21 g), mp 230–231 °C. [Found: C, 57.37; H, 4.51; N, 17.77. $C_{15}H_{14}N_4O_4$ requires C, 57.32; H, 4.49; N, 17.83%.] ν_{max} (KBr, cm^{-1}) 1635, 1675, 1722, 1740, 1755, 3230; δ_H (200 MHz, DMSO-d_6) 2.97 (3H, s, *Me*), 3.15 (3H, s, *Me*), 6.21 (1H, s, =C*H*–), 7.26–7.35 (5H, m, Ph), 9.08 (1H, s, N*H*), 11.66 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 28.0, 28.1, 63.5, 91.4, 128.3, 128.7, 129.3, 138.4, 151.6, 155.4, 160.6, 164.3, 171.9; MS, *m*/*z* (*I*, %): 314 ($M^{+\bullet}$, 100).

4.4.2. 8,10-Dimethyl-4-(p-tolyl)-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7b**)

The title compound was obtained as a colorless solid in 64% yield (0.21 g), mp 226–227 °C. [Found: C, 58.48; H, 4.95; N, 17.09. $C_{16}H_{16}N_4O_4$ requires C, 58.53; H, 4.91; N, 17.06%.] ν_{max} (KBr, cm^{-1}) 1628, 1676, 1719, 1743, 1762, 3253; δ_H (200 MHz, DMSO-d_6) 2.24 (3H, s, *Me*Ar), 2.97 (3H, s, *Me*), 3.15 (3H, s, *Me*), 6.17 (1H, s, =C*H*–), 7.05–7.12 (4H, m, Ar), 9.04 (1H, s, N*H*), 11.54 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 21.2, 28.0, 28.1, 63.0, 91.3, 128.5, 129.9, 136.9, 138.2, 151.5, 155.2, 160.5, 164.0, 171.7; MS, *m*/*z* (*I*, %): 328 ($M^{+\bullet}$, 100).

4.4.3. 4-(4-Bromophenyl)-8,10-dimethyl-1,3,8,10-tetraazaspiro-[5,5]-undec-4-ene-2,7,9,11-tetraone (**7c**)

The title compound was obtained as a colorless solid in 66% yield (0.26 g), mp 228–229 °C. [Found: C, 45.86; H, 3.28; N, 14.20. $C_{15}H_{13}BrN_4O_4$ requires C, 45.82; H, 3.33; N, 14.25%.] ν_{max} (KBr, cm^{-1}) 1625, 1670, 1715, 1755, 3245; δ_H (200 MHz, DMSO-d_6) 2.96 (3H, s, *Me*), 3.15 (3H, s, *Me*), 6.20 (1H, s, =C*H*–), 7.20 (2H, d, *J* 8.5 Hz, *o*-Ar), 7.50 (2H, d, *J* 8.5 Hz, *m*-Ar), 9.11 (1H, s, N*H*), 11.56 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 28.0, 28.1, 62.8, 91.4, 121.8, 130.5, 132.2, 137.8, 151.6, 154.4, 160.7, 164.2, 171.3; MS, *m*/*z* (*I*, %): 392 (100), 394 ($M^{+\bullet}$, 98).

4.4.4. 8,10-Dimethyl-4-(4-iodophenyl)-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7d**)

The title compound was obtained as a colorless solid in 68% yield (0.30 g), mp 249–250 °C. [Found: C, 40.89; H, 3.03; N, 12.78. $C_{15}H_{13}IN_4O_4$ requires C, 40.93; H, 2.98; N, 12.73%.] ν_{max} (KBr, cm^{-1}) 1632, 1677, 1722, 1760, 3235; δ_H (200 MHz, DMSO-d_6) 2.97 (3H, s, *Me*), 3.15 (3H, s, *Me*), 6.17 (1H, s, =C*H*–), 7.05 (2H, d, *J* 8.2 Hz, *o*-Ar), 7.68 (2H, d, *J* 8.2 Hz, *m*-Ar), 9.08 (1H, s, N*H*), 11.66 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 28.0, 28.1, 62.9, 91.3, 96.0, 131.2, 138.0, 139.2, 151.5, 155.4, 160.6, 164.3, 171.3; MS, *m*/*z* (*I*, %): 440 ($M^{+\bullet}$, 100).

4.4.5. 8,10-Dimethyl-4-(4-nitrophenyl)-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7e**)

The title compound was obtained as a colorless solid in 72% yield (0.26 g), mp 242–243 °C. [Found: C, 50.25; H, 3.59; N, 19.37. $C_{15}H_{13}N_5O_6$ requires C, 50.14; H, 3.65; N, 19.49%.] ν_{max} (KBr, cm^{-1}) 1633, 1679, 1722, 1757, 3245; δ_H (200 MHz, DMSO-d_6) 2.92 (3H, s, *Me*), 3.17 (3H, s, *Me*), 6.36 (1H, s, =C*H*–), 7.53 (2H, d, *J* 8.1 Hz, *o*-Ar), 8.17 (2H, d, *J* 8.1 Hz, *m*-Ar), 9.19 (1H, s, N*H*), 11.59 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 28.0, 28.1, 62.7, 91.7, 124.8, 129.6, 145.6, 147.7, 151.6, 155.4, 160.8, 164.0, 170.4; MS, *m*/*z* (*I*, %): 359 ($M^{+\bullet}$, 100).

4.4.6. 8,10-Dimethyl-4-phenyl-1-(p-tolyl)-1,3,8,10-tetraazaspiro-[5,5]-undec-4-ene-2,7,9,11-tetraone (**7f**)

The title compound was obtained as a colorless solid in 74% yield (0.30 g), mp 217–218 °C. [Found: C, 65.26; H, 4.90; N, 13.96. $C_{22}H_{20}N_4O_4$ requires C, 65.34; H, 4.98; N, 13.85%.] ν_{max} (KBr, cm^{-1}) 1627, 1675, 1719, 1755, 3235; δ_H (200 MHz, DMSO-d_6) 2.26 (3H, s, *Me*–NAr), 3.06 (3H, s, *Me*), 3.33 (3H, s, *Me*), 6.85 (1H, s, =C*H*–), 7.07 (2H, d, *J* 7.9 Hz, *m*-NAr), 7.18 (2H, d, *J* 7.9 Hz, *o*-NAr), 7.23–7.34 (5H, m, Ph), 11.96 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 20.9, 28.1, 66.6, 91.4, 128.7, 129.8, 131.8, 132.9, 123.6, 128.8, 129.0, 135.4, 151.2, 152.3, 160.2 163.8, 168.9; MS, *m*/*z* (*I*, %): 404 ($M^{+\bullet}$, 100).

*4.4.7. 8,10-Dimethyl-1-(2-fluorophenyl)-4-phenyl-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7g**)*

The title compound was obtained as a colorless solid in 39% yield (0.16 g), mp 192–194 °C. [Found: C, 61.69; H, 4.27; N, 13.76. $C_{21}H_{17}FN_4O_4$ requires C, 61.76; H, 4.20; N, 13.72%.] ν_{max} (KBr, cm^{-1}) 1635, 1676, 1721, 1759, 3249; δ_H (200 MHz, DMSO-d_6) 2.97 (3H, s, *Me*), 3.18 (3H, s, *Me*), 6.72 (1H, s, =C*H*–), 7.16–7.26 (8H, m, Ph+NAr), 7.42 (1H, t, *J* 7.6 Hz, NAr), 12.05 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 28.1, 28.2, 68.1, 92.2, 128.9, 129.9, 130.5, 138.3, 117.0, 122.7, 125.7, 130.3, 132.0, 156.6, 151.4, 159.9, 160.4, 163.9, 169.4; MS, *m*/*z* (*I*, %): 408 ($M^{+\bullet}$, 100).

*4.4.8. 8,10-Dimethyl-1-(2-methoxyethyl)-4-phenyl-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7h**)*

The title compound was obtained as a colorless solid in 63% yield (0.23 g), mp 117–118 °C. [Found: C, 57.98; H, 5.35; N, 15.47. $C_{18}H_{20}N_4O_5$ requires C, 58.06; H, 5.41; N, 15.05%.] ν_{max} (KBr, cm^{-1}) 1629, 1675, 1722, 1740, 1755, 3230; δ_H (200 MHz, DMSO-d_6) 2.96 (3H, s, *Me*), 3.13 (3H, s, *Me*), 3.18 (3H, s, O*Me*), 3.28–3.40 (2H, m, CH_2CH_2OMe), 3.54–3.66 (2H, m, CH_2CH_2OMe), 6.26 (1H, s, =C*H*–), 7.29–7.34 (5H, m, Ph), 11.75 (1H, s, NH); δ_C (100 MHz, DMSO-d_6) 27.9, 40.0, 58.5, 66.0, 70.2, 91.3, 128.2, 128.6, 130.0, 137.5, 151.3, 153.6, 160.4, 163.5, 167.0; MS, *m*/*z* (*I*, %): 372 ($M^{+\bullet}$, 100).

*4.4.9. 8,10-Dimethyl-1-(2-fluorophenyl)-4-(p-tolyl)-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7i**)*

The title compound was obtained as a colorless solid in 62% yield (0.26 g), mp 203–204 °C. [Found: C, 62.51; H, 4.58; N, 13.22. $C_{22}H_{19}FN_4O_4$ requires C, 62.56; H, 4.50; N, 13.27%.] ν_{max} (KBr, cm^{-1}) 1633, 1675, 1721, 1757, 3240; δ_H (200 MHz, DMSO-d_6) 2.14 (3H, s, *Me*Ar), 3.00 (3H, s, *Me*), 3.17 (3H, s, *Me*), 6.69 (1H, s, =C*H*–), 6.96–7.02 (4H, m, *m*-Ar+NAr), 7.15–7.27 (3H, m, *o*-Ar+NAr), 7.43 (1H, t, *J* 7.6 Hz, NAr), 12.08 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 21.2, 28.1, 28.2, 68.2, 92.1, 125.6, 129.6, 137.2, 138.5, 117.0, 122.7, 125.7, 130.3, 132.0, 156.6, 151.5, 159.9, 160.5, 164.0, 169.5; MS, *m*/*z* (*I*, %): 422 ($M^{+\bullet}$, 100).

*4.4.10. 1-(3-Chlorophenyl)-8,10-dimethyl-4-(p-tolyl)-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7j**)*

The title compound was obtained as a colorless solid in 64% yield (0.28 g), mp 205–206 °C. [Found: C, 60.24; H, 4.41; N, 12.71. $C_{22}H_{19}ClN_4O_4$ requires C, 60.21; H, 4.36; N, 12.77%.] ν_{max} (KBr, cm^{-1}) 1627, 1676, 1721, 1760, 3242; δ_H (200 MHz, DMSO-d_6) 2.15 (3H, s, *Me*Ar), 3.05 (3H, s, *Me*), 3.20 (3H, s, *Me*), 6.98 (1H, s, =C*H*–), 7.03 (2H, d, *J* 8.2 Hz, *m*-Ar), 7.12–7.36 (3H, m, NAr), 7.43 (2H, d, *J* 8.2 Hz, *o*-Ar), 7.68 (1H, s, NAr), 12.03 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 21.1, 28.1, 28.2, 66.8, 91.3, 128.6, 129.9, 137.1, 138.2, 126.0, 127.8, 131.0, 133.7, 136.2, 139.5, 151.3, 158.9, 160.1, 163.9, 168.5; MS, *m*/*z* (*I*, %): 438 (100), 440 ($M^{+\bullet}$, 30).

*4.4.11. 4-(4-Chlorophenyl)-8,10-dimethyl-1-(2-methoxyethyl)-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7k**)*

The title compound was obtained as a colorless solid in 67% yield (0.27 g), mp 140–141 °C. [Found: C, 53.19; H, 4.75; N, 13.69. $C_{18}H_{19}ClN_4O_5$ requires C, 53.14; H, 4.71; N, 13.77%.] ν_{max} (KBr, cm^{-1}) 1625, 1670, 1720, 1758, 3235; δ_H (200 MHz, DMSO-d_6) 3.00 (3H, s, *Me*), 3.15 (3H, s, *Me*), 3.20 (3H, s, O*Me*), 3.26–3.36 (2H, m, CH_2CH_2OMe), 3.50–3.60 (2H, m, CH_2CH_2OMe), 6.25 (1H, s, =C*H*–), 7.29 (2H, d, *J* 8.5 Hz, *m*-Ar), 7.40 (2H, d, *J* 8.5 Hz, *o*-Ar), 11.76 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 27.9, 40.1, 58.5, 65.9, 70.2, 91.4, 128.9, 131.0, 134.6, 135.5, 151.3, 153.8, 160.4, 163.8, 167.4; MS, *m*/*z* (*I*, %): 406 (100), 408 ($M^{+\bullet}$, 30).

*4.4.12. 4-(4-Bromophenyl)-8,10-dimethyl-1-(p-tolyl)-1,3,8,10-tetrazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7l**)*

The title compound was obtained as a colorless solid in 69% yield (0.33 g), mp 206–207 °C. [Found: C, 54.61; H, 3.80; N, 11.48. $C_{22}H_{19}BrN_4O_4$ requires C, 54.67; H, 3.96; N, 11.59%.] ν_{max} (KBr, cm^{-1}) 1630, 1675, 1722, 1765, 3245; δ_H (200 MHz, DMSO-d_6) 2.19 (3H, s, *Me*–NAr), 3.01 (3H, s, *Me*), 3.16 (3H, s, *Me*), 6.90 (1H, s, =C*H*–), 7.09 (2H, d, *J* 8.0 Hz, *m*-NAr), 7.26 (2H, d, *J* 8.2 Hz, *o*-Ar), 7.33 (2H, d, *J* 8.4 Hz, *m*-Ar), 7.41 (2H, d, *J* 8.0 Hz, *o*-NAr), 11.97 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 20.9, 28.1, 66.6, 91.4, 123.6, 130.1, 131.4, 132.9, 122.0, 131.7, 135.6, 136.6, 151.2, 152.3, 160.3, 163.7, 168.4; MS, *m*/*z* (*I*, %): 482 (100), 484 ($M^{+\bullet}$, 99).

*4.4.13. 8,10-Dimethyl-1-(p-tolyl)-4-(thiophen-2-yl)-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**7m**)*

The title compound was obtained as a colorless solid in 62% yield (0.25 g), mp 232–233 °C. [Found: C, 58.62; H, 4.37; N, 13.52; S, 7.70. $C_{20}H_{18}N_4O_4S$ requires C, 58.53; H, 4.42; N, 13.65; S, 7.80%.] ν_{max} (KBr, cm^{-1}) 1627, 1675, 1720, 1760, 3240; δ_H (200 MHz, DMSO-d_6) 2.22 (3H, s, *Me*Ar), 3.09 (3H, s, *Me*), 3.17 (3H, s, *Me*), 6.84 (1H, t, *J* 4.6 Hz, β-thienyl), 7.11–7.16 (3H, m, *m*-NAr+β-thienyl), 7.25 (1H, s, =C*H*–), 7.36–7.40 (3H, m, *o*-NAr+α-thienyl), 11.87 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 21.1, 28.3, 62.8, 92.9, 129.4, 133.2, 135.6, 137.5, 123.0, 127.2, 127.3, 130.1, 151.4, 152.1, 160.6, 163.7, 168.4; MS, *m*/*z* (*I*, %): 410 ($M^{+\bullet}$, 100).

General procedure B: one-pot procedure. A mixture of 1,3-dimethylbarbituric acid (**1**) (1 mmol), the appropriate arylglyoxals **2a**,**d** (1 mmol), and ureas **5a**,**b** (1 mmol) was heated at reflux in methanol for 1–1.5 h. The resulting product was filtered off, washed with cold methanol or recrystallized. Spiranes **7a**,**d**,**f** were prepared in this way.

4.5. Preparation of 1-acetyl-4-aryl-8,10-dimethyl-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraones (8a–c)

General procedure. Spiroproducts **7a**,**b**,**d** (1 mmol) were heated at reflux in acetic anhydride (10 mmol) containing catalytic amounts of sulfuric acid for 5–10 min. The precipitates of compounds **8a**–**c** were filtered off and washed with water twice.

*4.5.1. 1-Acetyl-8,10-dimethyl-4-phenyl-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**8a**)*

The title compound was obtained as a colorless solid in 77% yield (0.27 g), mp 222–223 °C. [Found: C, 57.44; H, 4.45; N, 15.81. $C_{17}H_{16}N_4O_5$ requires C, 57.30; H, 4.53; N, 15.72%.] ν_{max} (KBr, cm^{-1}) 1632, 1668, 1679, 1722, 1770, 3235; δ_H (200 MHz, DMSO-d_6) 2.32 (3H, s, *Me*), 3.03 (6H, s, 2N*Me*), 6.62 (1H, s, =C*H*–), 7.18–7.29 (5H, m, Ph), 12.02 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 24.5, 28.2, 63.3, 92.6, 128.3, 129.2, 129.8, 137.5, 151.4, 152.7, 160.5, 163.8, 168.0, 168.4; MS, *m*/*z* (*I*, %): 356 ($M^{+\bullet}$, 100).

*4.5.2. 1-Acetyl-8,10-dimethyl-4-(p-tolyl)-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**8b**)*

The title compound was obtained as a colorless solid in 72% yield (0.27 g), mp 226–227 °C. [Found: C, 58.43; H, 4.93; N, 15.23. $C_{18}H_{18}N_4O_5$ requires C, 58.37; H, 4.90; N, 15.13%.] ν_{max} (KBr, cm^{-1}) 1631, 1650, 1672, 1729, 1773, 3230; δ_H (200 MHz, DMSO-d_6) 2.23 (3H, s, *Me*Ar), 2.33 (3H, s, *Me*), 3.02 (3H, s, N*Me*), 3.16 (3H, s, N*Me*), 6.63 (1H, s, =C*H*–), 7.08 (2H, d, *J* 7.9 Hz, *m*-Ar), 7.23 (2H, d, *J* 7.9 Hz, *o*-Ar), 11.90 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 21.2, 24.5, 28.2, 63.5, 92.7, 129.3, 129.4, 133.6, 138.4, 151.4, 152.7, 160.5, 163.8, 167.9, 168.3; MS, *m*/*z* (*I*, %): 370 ($M^{+\bullet}$, 100).

*4.5.3. 1-Acetyl-8,10-dimethyl-4-(4-iodophenyl)-1,3,8,10-tetraazaspiro[5,5]-undec-4-ene-2,7,9,11-tetraone (**8c**)*

The title compound was obtained as a colorless solid in 74% yield (0.36 g), mp 230–232 °C. [Found: C, 42.42; H, 3.20; N, 11.57. $C_{17}H_{15}IN_4O_5$ requires C, 42.34; H, 3.14; N, 11.62%.] ν_{max} (KBr, cm^{-1}) 1632, 1660, 1675, 1725, 1771, 3240; δ_H (200 MHz, DMSO-d_6) 2.32 (3H, s, *Me*), 2.99 (3H, s, N*Me*), 3.14 (3H, s, N*Me*), 6.55 (1H, s, =C*H*–), 7.13 (2H, d, *J* 8.2 Hz, *o*-Ar), 7.65 (2H, d, *J* 8.2 Hz, *m*-Ar), 12.04 (1H, s, N*H*); δ_C (100 MHz, DMSO-d_6) 24.5, 28.2, 63.9, 92.9, 95.5, 131.8, 136.3, 137.5, 151.4, 152.6, 160.6, 163.7, 167.0, 168.5; MS, *m*/*z* (*I*, %): 482 ($M^{+\bullet}$, 100).

4.6. Synthesis of 5-(5-aryl-1,3-dimethyl-2-oxo-2,3-dihydro-1*H*-imidazol-4-yl)-1,3-dimethylpyrimidine-2,4,6-triones (9b,c,e)

General procedure A: (one-pot synthesis). Equimolar amounts of **1**, **2c**,**e**, and **5f** (1.0 mmol) were dissolved in methanol (5–7 mL) and heated at reflux for 25–40 min. Crystals of **9c**,**e** were filtered off, washed with water and hot methanol.

*4.6.1. 5-(5-(4-Chlorophenyl)-1,3-dimethyl-2-oxo-2,3-dihydro-1H-imidazol-4-yl)-1,3-dimethylpyrimidine-2,4,6-trione (**9c**)*

The title compound was obtained as a colorless solid in 87% yield (0.33 g), mp 254–255 °C. [Found: C, 54.24; H, 4.63; N, 14.92. $C_{17}H_{17}ClN_4O_4$ requires C, 54.19; H, 4.55; N, 14.87%.] ν_{max} (KBr, cm^{-1}) 1630, 1674, 1702; δ_H (200 MHz, DMSO-d_6) 2.91 (3H, s, *Me*), 3.10 (3H, s, *Me*), 3.13 (6H, s, 2N*Me*), 3.49 (1H, s, C*H*), 7.25 (2H, d, *J* 8.0 Hz, *m*-Ar), 7.40 (2H, d, *J* 8.0 Hz, *o*-Ar); δ_C (100 MHz, DMSO-d_6) 27.9, 28.9, 29.2, 80.0, 112.8, 132.9, 122.9, 129.1, 129.3, 130.8, 151.7, 154.0, 162.1; MS, *m*/*z* (*I*, %): 376 (100), 378 ($M^{+\bullet}$, 33).

*4.6.2. 5-(5-(4-Iodophenyl)-1,3-dimethyl-2-oxo-2,3-dihydro-1H-imidazol-4-yl)-1,3-dimethylpyrimidine-2,4,6-trione (**9e**)*

The title compound was obtained as a colorless solid in 67% yield (0.31 g), mp 198–200 °C. [Found: C, 43.70; H, 3.71; N, 12.05. $C_{17}H_{17}IN_4O_4$ requires C, 43.61; H, 3.66; N, 11.97%.] ν_{max} (KBr, cm^{-1}) 1632, 1670, 1705; δ_H (200 MHz, DMSO-d_6) 2.89 (3H, s, *Me*), 3.08 (3H, s, *Me*), 3.12 (6H, s, 2N*Me*), 3.67 (1H, s, C*H*), 7.03 (2H, d, *J* 7.9 Hz, *o*-Ar), 7.67 (2H, d, *J* 7.9 Hz, *m*-Ar); δ_C (100 MHz, DMSO-d_6) 27.8, 28.8, 29.3, 79.8, 113.1, 131.1, 94.4, 129.9, 123.0, 138.0, 151.9, 154.0, 162.3; MS, *m*/*z* (*I*, %): 468 ($M^{+\bullet}$, 100).

General procedure B. A mixture of enones **3b**,**e** (1.0 mmol) and **5f** (1.0 mmol) were heated at reflux in methanol (5–7 mL) for 1–1.5 h. The products **9b**,**e** were filtered off, washed with cold methanol or recrystallized.

*4.6.3. 5-(1,3-Dimethyl-2-oxo-5-(p-tolyl)-2,3-dihydro-1H-imidazol-4-yl)-1,3-dimethylpyrimidine-2,4,6-trione (**9b**)*

The title compound was obtained as a colorless solid in 62% yield (0.22 g), mp 220–221 °C. [Found: C, 60.59; H, 5.72; N, 15.64. $C_{18}H_{20}N_4O_4$ requires C, 60.66; H, 5.66; N, 15.72%.] ν_{max} (KBr, cm^{-1}) 1629, 1667, 1702; δ_H (200 MHz, DMSO-d_6) 2.26 (3H, s, *Me*Ar), 2.89 (3H, s, *Me*), 3.07 (3H, s, *Me*), 3.12 (6H, s, 2 N*Me*), 3.47 (1H, s, C*H*), 7.10–7.16 (4H, m, Ar); δ_C (100 MHz, DMSO-d_6) 21.2, 27.8, 28.8, 29.3, 80.0, 112.9, 131.5, 128.3, 129.0, 131.0, 137.8, 151.8, 154.0, 162.2; MS, *m*/*z* (*I*, %): 356 ($M^{+\bullet}$, 100).

4.7. 5-(2-Amino-4-phenylthiazol-5-yl)-6-hydroxy-1,3-dimethylpyrimidine-2,4-dione (13)

A mixture of enone **3a** (1.0 mmol) and thiourea (**12**) (1.0 mmol) was heated at reflux in ethanol (8–10 mL) for 10 min. Product **13** as colorless solid was filtered off and washed with ethanol in 62% yield (0.20 g), mp >300 °C. [Found: C, 54.60; H, 4.36; N, 17.05; S, 9.73. $C_{15}H_{14}N_4O_3S$ requires C, 54.53; H, 4.27; N, 16.96; S, 9.71%.] ν_{max} (KBr, cm^{-1}) 1622, 1665, 1676, 3220, 3326; δ_H (200 MHz, DMSO-d_6) 3.01 (6H, s, 2*Me*), 7.23–7.43 (5H, m, Ph), 8.55 (2H, br s, NH_2), 12.75 (1H, br s, O*H*); δ_C (100 MHz, DMSO-d_6) 27.8, 78.0, 119.3, 132.0, 127.6, 128.6, 128.8, 131.6, 153.1, 161.8, 168.5, 167.0; MS, *m*/*z* (*I*, %): 330 ($M^{+\bullet}$, 100).

4.8. X-ray diffraction study of 9e

X-ray diffraction study of **9e** was performed on an 'Xcalibur 3' diffractometer at 300 K (graphite-monochromated Mo Kα radiation, CCD detector, ω-scans). Crystal data: $C_{17}H_{17}N_6O_6I$ (M_r=468.25), triclinic, $P\bar{1}$, a=9.7565(4), b=9.7935(4), c=11.4876(4) Å, α=112.298(4)°, β=94.054(3)°, γ=98.715(3)°, V=993.93(7) $Å^3$, Z=2, d_{calcd}=1.565 g cm^{-1}, μ=1.639, 26,491 reflections measured up to $2\theta_{max}$=30.0°, 5780 were independent (R_{int}=0.021). Structure was solved by direct method and refined of F^2 within anisotropic approximation for all non-hydrogen atoms using SHELXTL[28] package. All H atoms were placed in idealized positions (C–H=0.93–0.98 Å, O–H=0.82 Å) and constrained to ride on their parent atoms, with U_{iso}=1.2 U_{eq} (except U_{iso}=1.5 U_{eq} for methyl and hydroxy groups). During the refinement, three isolated electron density peaks were located, which were believed to be a solvent molecule (possibly ethanol or water). Satisfactory results ($R_1[F^2>2\sigma(F^2)]$=0.046) were obtained modeling the disordered C and O atoms, but large displacement parameters for them were observed. SQUEEZE procedure implemented in PLATON[29] indicated a solvent cavity of volume 135 $Å^3$ centered at (0.5, 0, 0), containing approximately 14 electrons. In the final refinement, this contribution was removed from the intensity data that produced better refinement results. Final refinement converged to wR_2=0.120 (all data), R_1=0.035 (for 4311 reflections with $F^2>2\sigma(F^2)$), GOF=1.06. CCDC 670178 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

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