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Novel mercaptoacetylative expeditious annulation of 5-mercaptopyrimidine ring on azoles using 1,3-oxathiolan-5-one

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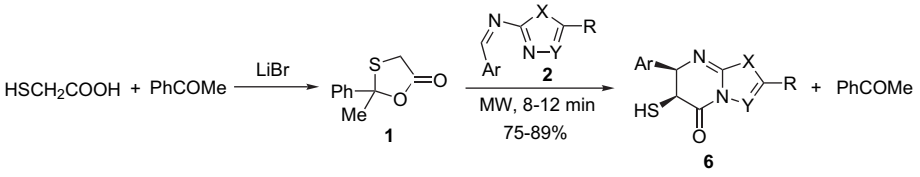
Abstract—Schiff bases of azoles containing the amino group as part of a partial amidine structure undergo mercaptoacetylative expeditious annulation with 2-methyl-2-phenyl-1,3-oxathiolan-5-one to yield highly substituted 6,7-dihydro-6-mercapto-5*H*-thiazolo/1,3,4-oxa(thia)-diazolo[3,2-*a*]pyrimidin-5-ones stereoselectively. The annulation is effected via an isolable intermediate under solvent-free microwave irradiation conditions in a one-pot procedure.

1. Introduction

Pyrimidines and azoles have a long history of applications in pharmaceutical and agrochemical industries.[1–6] Thus, heterocyclic systems resulting from the annulation of a pyrimidine ring on biologically versatile azoles appear to be attractive scaffolds to be utilised for exploiting chemical diversity. Highly substituted heterocycles are interesting as potential biodegradable pharmaceuticals and agrochemicals.[7–9] It is well known that the presence of a thiol function in many enzymes, called '–SH enzymes', is essential for their enzyme activity. Likewise, incorporation of a thiol



2-6	R	X	Y	Ar
a	Ph	O	N	Ph
b	Ph	O	N	4-ClC_6H_4
c	Ph	O	N	4-$MeOC_6H_4$
d	4-ClC_6H_4	O	N	Ph
e	4-ClC_6H_4	O	N	4-ClC_6H_4
f	4-ClC_6H_4	O	N	4-$MeOC_6H_4$
g	Ph	S	N	Ph
h	Ph	S	N	4-ClC_6H_4
i	Ph	S	N	4-$MeOC_6H_4$
j	H	S	C-Ph	Ph
k	H	S	C-Ph	4-ClC_6H_4
l	H	S	C-Ph	4-$MeOC_6H_4$

Scheme 1.

Keywords: Solvent-free; Microwaves; Schiff bases; Stereoselective synthesis; Azolo-pyrimidines.
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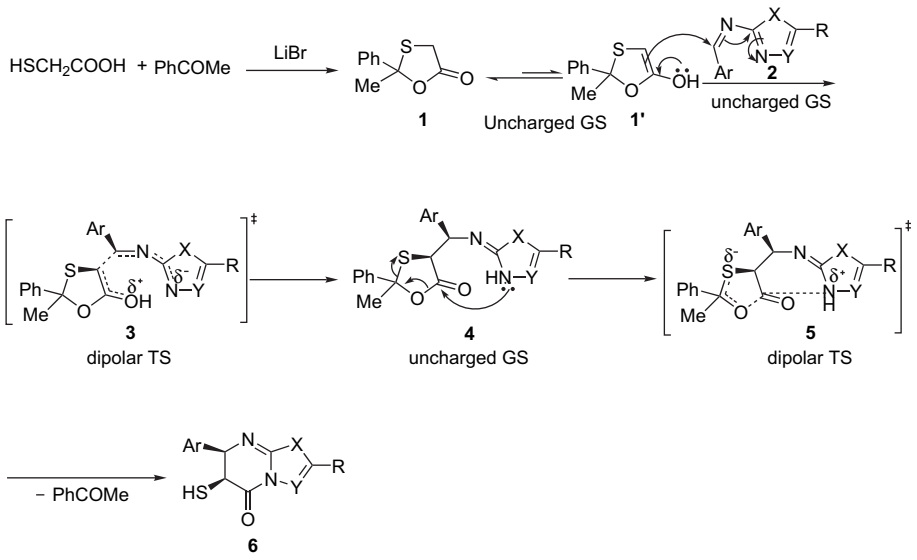

Scheme 2.

function in heterocycles, nucleosides, or nucleotides has led to a number of analogues possessing interesting biological and therapeutic properties.[10–17] Azolo-pyrimidines **6** incorporating a thiol function are hitherto unreported, and neither classical synthetic approaches to heterocycles nor classical functionalisation reactions of heterocycles can be readily used for their synthesis.

We have previously reported diastereoselective synthetic protocols for annulating pyrimidine ring on azoles incorporating an amino function at C-6 employing glycine derivatives.[18–22] As part of an ongoing programme of research, we had to develop a rapid and efficient synthetic approach to azolo-pyrimidine heterocyclic systems **6** incorporating a thiol function at C-6. For this purpose, we utilised the recently reported mercaptoacetyl transfer agent, 2-methyl-2-phenyl-1,3-oxathiolan-5-one **1**,[23] which leads to the desired mercaptoacetylative heteroannulation and is the key element in the present successful synthetic strategy for the target compounds **6** (Scheme 1). It is noteworthy that acetophenone, which is used to activate mercaptoacetic acid to act as a novel and efficient mercaptoacetyl transfer agent **1**, is automatically removed during the reactions yielding compounds **6**.

In order to achieve our goal expeditiously, we relied upon significant advantages of solvent-free microwave (MW) irradiation such as enhanced reaction rates, higher yields of pure products, easier work-up, rapid optimisation of reactions in parallel and several eco-friendly advantages in the context of green chemistry.[24–28] The application of MW irradiation to provide enhanced reaction rates and improved product yields in chemical synthesis has been extended to modern drug discovery processes,[29,30] and it is proving quite successful in the formation of carbon–heteroatom and carbon–carbon bonds.[31,32] Interestingly, the conjugate addition of **1** to azole Schiff bases **2** followed by ring transformation of the isolable adducts **4** to azolo-pyrimidinones **6** (Scheme 2) are among the few examples showing increased stereoselectivity under MW irradiation compared to conventional heating.

2. Results and discussion

After some preliminary experimentation, it was found that the envisaged annulation was successful with an intimate mixture of 2-methyl-2-phenyl-1,3-oxathiolan-5-one **1** and an azole Schiff base **2** under MW irradiation of 100 W in a CEM Discover microwave system for the time specified in Table 1. Isolation and purification by recrystallisation from ethanol afforded the azolo-pyrimidin-5-ones **6** in 75–89% yield (Table 1) with >95% diastereoselectivity.

For comparison purposes, the final temperature of the reaction mixture was recorded immediately after the MW irradiation and found to be <80 °C. The reactions were also carried out using a thermostated oil-bath at the same temperature (80 °C) as for the MW-activated method but for a longer (optimised) period of time (Table 1) to ascertain whether the MW method improves the yield or simply increases conversion rates. It was found that significantly lower yields

Table 1. Solvent-free microwave-activated synthesis of products **4** and **6**

Product	Time		Yield (%)[c,d]	
	MW[a] (min)	Thermal[b] (h)	MW	Thermal
4a	4	8	48	40
4h	4	8	51	45
4k	4	8	43	40
6a	12	14	76	44
6b	10	12	80	48
6c	12	13	78	45
6d	12	14	77	46
6e	8	12	89	52
6f	8	13	85	49
6g	12	14	75	43
6h	10	13	78	46
6i	12	14	77	45
6j	12	14	75	44
6k	10	13	77	45
6l	12	14	79	47

[a] Microwave irradiation time (power=100 W).
[b] Time for oil-bath heating at 80 °C.
[c] Yield of isolated and purified products.
[d] All compounds gave C, H and N analyses within ±0.35% and satisfactory spectral (IR, ^{1}H NMR, ^{13}C NMR and EIMS) data.

(40–52%) were obtained using oil-bath heating rather than the MW-activated method (Table 1).

This observation may be rationalised on the basis of the formation of a dipolar transition state (TS) from an uncharged ground state (GS) in these reactions (Scheme 2), and the greater stabilisation of more polar TS by dipole–dipole interactions with the electric field of microwaves as compared to the less polar GS, which may reduce the activation energy ($\Delta G^{\neq}$) resulting in the rate enhancement.[24]

The formation of **6** is rationalised by the conjugate addition of oxathiolan-5-one **1** to azole Schiff bases **2** to furnish adducts **4**, which undergo intramolecular nucleophilic attack of the nitrogen atom of the azole ring (*N*-3) at the carbonyl carbon (*C*-5) of the oxathiolan-5-one nucleus to yield **6** with the elimination of acetophenone (Scheme 2). This conclusion is based on the observation that the representative intermediate compounds **4a**, **4h** and **4k** could be isolated in 43–51% yield, these could be converted into the corresponding annulated products **6a**, **6h** and **6k** in quantitative yield, and that acetophenone was formed during the reaction (Scheme 2).

The formation of adducts **4** and their annulation to **6** were highly diastereoselective in favour of cis isomers. The diastereomeric ratios of the crude products were checked by ^{1}H NMR, prior to purification to ensure accurate and true diastereomeric ratios are reported. The diastereomeric ratio for compounds **6** in the case of MW activation was found to be >95:<5 and that from the oil-bath heating was >56:<44 as determined by ^{1}H NMR spectroscopy. The high diastereoselectivity (>95%) in favour of cis isomers under MW irradiation may be explained by considering that MW irradiation favours the reactions occurring via more polar TS[24] and that the TS leading to the formation of cis isomers is more polar than that leading to the trans isomer because, in general, cis isomers are more polar than the trans.[33]

3. Conclusion

In summary, we have developed a novel mercaptoacetic acid-based one-pot synthetic protocol for an expeditious and highly diastereoselective synthesis of potentially pharmaceutically and agrochemically useful 6-mercaptoazolo-pyrimidin-5-ones starting from readily available simple substrates employing solvent-free microwave irradiation conditions.

4. Experimental

4.1. General

Melting points were determined by open glass capillary method and are uncorrected. IR spectra in KBr were recorded on a Perkin–Elmer 993 IR spectrophotometer, ^{1}H NMR spectra were recorded on a Bruker WM-40 C (400 MHz) FT spectrometer in DMSO-d_6 using TMS as internal reference. ^{13}C NMR spectra were recorded on the same instrument at 100 MHz using the same solvent and internal reference. Mass spectra were recorded on a JEOL D-300 mass spectrometer. Elemental analyses were carried out in a Coleman automatic carbon, hydrogen and nitrogen analyser. A CEM Discover Focused Microwave Synthesis System operating at 2450 MHz was used at an output of 100 W for all the experiments. All chemicals used were reagent grade and were used as received without further purification. Silica gel-G was for TLC.

4.2. 2-Methyl-2-phenyl-1,3-oxathiolan-5-one 1

It was prepared by the condensation of acetophenone and mercaptoacetic acid in the presence of lithium bromide according to the recently reported method.[23]

4.3. 2,7-Diaryl-6,7-dihydro-6-mercapto-5*H*-thiazolo/1,3,4-oxa(thia)diazolo[3,2-*a*]pyrimidin-5-ones 6. General procedure

Thoroughly mixed 2-methyl-2-phenyl-1,3-oxathiolan-5-one **1** (2.0 mmol) and an azole Schiff base **2** (2.0 mmol) were taken in a 10 mL vial and subjected to MW irradiation at 100 W in a CEM Discover microwave system for 2 min. The reaction mixture was then thoroughly mixed outside the MW oven for 2 min and again irradiated for another 2 min. This intermittent irradiation-mixing cycle was repeated for the total irradiation time (Table 1). After completion of the reaction as indicated by TLC (hexane/AcOEt, 8:2, v/v), water (10 mL) was added to the reaction mixture and stirred well. The yellowish precipitate thus obtained was washed with water to give the crude product which was recrystallised from ethanol to afford a diastereomeric mixture (>95:<5; in the crude products the ratio was >94:<6 as determined by ^{1}H NMR spectroscopy). The product on second recrystallisation from ethanol furnished an analytically pure sample of a single diastereomer **6** (Table 1). On the basis of comparison of J values to literature ones,[18,34–38] the cis stereochemistry was assigned to **6**, as the coupling constant ($J_{6,7}$=4 Hz) for **6** was lower than that for very minor (<5%) diastereomer (trans), $J_{6,7}$=10 Hz.

4.3.1. Compound 6a. Yellowish needles (2.45 g, 76%), mp 215–217 °C. IR (KBr) ν_{max} 3046, 2550, 1680, 1602, 1586, 1446, 1310 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.59 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 6.64 (d, 1H, J=4 Hz, H-7), 6.77 (dd, 1H, J=4, 8 Hz, H-6), 7.12–8.00 (m, 10H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 61.4 (7-C), 64.7 (6-C), 127.4, 128.2, 128.9, 129.6, 130.2, 130.9, 131.6, 132.6 (2×Ph), 159.6 (SC=N), 161.1 (2-C), 172.3 (C=O). Mass (m/z): 323 (M^+). Anal. Calcd for $C_{17}H_{13}N_3O_2S$: C, 63.14; H, 4.05; N, 12.99%. Found: C, 63.45; H, 4.29; N, 12.79%.

4.3.2. Compound 6b. Yellowish needles (2.86 g, 80%), mp 225–227 °C. IR (KBr) ν_{max} 3055, 2561, 1683, 1605, 1581, 1451, 1315 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.61 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 6.64 (d, 1H, J=4 Hz, H-7), 6.79 (dd, 1H, J=4, 8 Hz, H-6), 7.16–8.01 (m, 9H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 61.4 (7-C), 64.7 (6-C), 127.2, 128.0, 128.6, 129.3, 130.0, 130.8, 131.7, 132.5 (Ph, 4-ClC_6H_4), 159.7 (SC=N), 161.2 (2-C), 172.0 (C=O). Mass (m/z): 357 (M^+). Anal. Calcd for $C_{17}H_{12}ClN_3O_2S$: C, 57.06; H, 3.38; N, 11.74%. Found: C, 57.41; H, 3.58; N, 11.94%.

4.3.3. Compound 6c. Yellowish needles (2.75 g, 78%), mp 220–221 °C. IR (KBr) ν_{max} 3061, 2582, 1685, 1604, 1576,

1460, 1320 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 1.60 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 3.75 (s, 3H, OMe), 6.65 (d, 1H, J=4 Hz, H-7), 6.78 (dd, 1H, J=4, 8 Hz, H-6), 7.13–7.99 (m, $9H_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 54.6 (OMe), 61.5 (7-C), 64.8 (6-C), 127.3, 128.1, 128.9, 129.5, 130.3, 131.0, 131.6, 132.5 (Ph, 4-$MeOC_6H_4$), 159.8 (SC=N), 161.3 (2-C), 172.3 (C=O). Mass (*m*/*z*): 353 (M^+). Anal. Calcd for $C_{18}H_{15}N_3O_3S$: C, 61.18; H, 4.28; N, 11.89%. Found: C, 61.48; H, 4.03; N, 11.65%.

4.3.4. Compound 6d. Yellowish needles (2.75 g, 77%), mp 230–231 °C. IR (KBr) ν_{max} 3062, 2589, 1681, 1603, 1585, 1455, 1321 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 1.59 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 6.65 (d, 1H, J=4 Hz, H-7), 6.76 (dd, 1H, J=4, 8 Hz, H-6), 7.11–7.99 (m, $9H_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 61.5 (7-C), 64.5 (6-C), 127.4, 128.1, 128.9, 129.5, 130.8, 131.6, 132.3, 133.0 (Ph, 4-ClC_6H_4), 159.8 (SC=N), 161.1 (2-C), 172.1 (C=O). Mass (*m*/*z*): 357 (M^+). Anal. Calcd for $C_{17}H_{12}ClN_3O_2S$: C, 57.06; H, 3.38; N, 11.74%. Found: C, 57.41; H, 3.58; N, 11.95%.

4.3.5. Compound 6e. Yellowish needles (3.50 g, 89%), mp 223–225 °C. IR (KBr) ν_{max} 3059, 2591, 1680, 1601, 1581, 1460, 1323 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 1.62 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 6.68 (d, 1H, J=4 Hz, H-7), 6.79 (dd, 1H, J=4, 8 Hz, H-6), 7.16–8.00 (m, $8H_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 61.6 (7-C), 64.6 (6-C), 127.5, 128.2, 129.0, 129.7, 130.7, 131.5, 132.2, 133.0 (2×4-ClC_6H_4), 159.7 (SC=N), 161.2 (2-C), 172.3 (C=O). Mass (*m*/*z*): 393 (M^+). Anal. Calcd for $C_{17}H_{11}Cl_2N_3O_2S$: C, 52.05; H, 2.83; N, 10.71%. Found: C, 52.40; H, 2.60; N, 10.96%.

4.3.6. Compound 6f. Yellowish needles (3.29 g, 85%), mp 215–216 °C. IR (KBr) ν_{max} 3058, 2565, 1680, 1602, 1582, 1458, 1312 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 1.61 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 3.74 (s, 3H, OMe), 6.66 (d, 1H, J=4 Hz, H-7), 6.78 (dd, 1H, J=4, 8 Hz, H-6), 7.12–8.01 (m, $8H_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 54.4 (OMe), 61.6 (7-C), 64.6 (6-C), 127.4, 128.1, 128.9, 129.8, 130.5, 131.2, 131.9, 132.7 (4-ClC_6H_4, 4-$MeOC_6H_4$), 159.7 (SC=N), 161.2 (2-C), 172.2 (C=O). Mass (*m*/*z*): 387 (M^+). Anal. Calcd for $C_{18}H_{14}ClN_3O_3S$: C, 55.74; H, 3.64; N, 10.83%. Found: C, 55.50; H, 3.89; N, 10.60%.

4.3.7. Compound 6g. Yellowish needles (2.54 g, 75%), mp 184–186 °C. IR (KBr) ν_{max} 3049, 2583, 1684, 1599, 1574, 1459, 1319 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 1.60 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 6.62 (d, 1H, J=4 Hz, H-7), 6.74 (dd, 1H, J=4, 8 Hz, H-6), 7.10–7.79 (m, $10H_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 61.6 (7-C), 64.8 (6-C), 127.2, 127.9, 128.6, 129.4, 130.2, 131.0, 131.8, 132.7 (2×Ph), 150.0 (2-C), 159.9 (SC=N), 172.4 (C=O). Mass (*m*/*z*): 339 (M^+). Anal. Calcd for $C_{17}H_{13}N_3OS_2$: C, 60.15; H, 3.86; N, 12.38%. Found: C, 60.50; H, 3.64; N, 12.15%.

4.3.8. Compound 6h. Yellowish needles (2.91 g, 78%), mp 168–169 °C. IR (KBr) ν_{max} 3055, 2581, 1681, 1602, 1586, 1440, 1311 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 1.62 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 6.64 (d, 1H, J=4 Hz, H-7), 6.77 (dd, 1H, J=4, 8 Hz, H-6), 7.10–7.79 (m, $9H_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 61.4 (7-C), 64.9 (6-C), 127.3, 128.0, 128.6, 129.6, 130.2, 131.0, 131.7, 132.6 (Ph, 4-ClC_6H_4), 150.3 (2-C), 160.1 (SC=N), 172.4 (C=O). Mass (*m*/*z*): 373 (M^+). Anal. Calcd for $C_{17}H_{12}ClN_3OS_2$: C, 54.61; H, 3.24; N, 11.24%. Found: C, 54.18; H, 3.49; N, 11.48%.

4.3.9. Compound 6i. Yellowish needles (2.84 g, 77%), mp 177–178 °C. IR (KBr) ν_{max} 3063, 2590, 1682, 1600, 1581, 1455, 1321 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 1.62 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 3.75 (s, 3H, OMe), 6.63 (d, 1H, J=4 Hz, H-7), 6.76 (dd, 1H, J=4, 8 Hz, H-6), 7.11–7.81 (m, $9H_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 54.3 (OMe), 61.5 (7-C), 64.7 (6-C), 127.2, 127.9, 128.6, 129.5, 130.6, 131.2, 132.0, 132.8 (Ph, 4-$MeOC_6H_4$), 150.1 (2-C), 160.0 (SC=N), 172.3 (C=O). Mass (*m*/*z*): 369 (M^+). Anal. Calcd for $C_{18}H_{15}N_3O_2S_2$: C, 58.52; H, 4.09; N, 11.37%. Found: C, 58.87; H, 4.34; N, 11.17%.

4.3.10. Compound 6j. Yellowish needles (2.45 g, 75%), mp 164–165 °C. IR (KBr) ν_{max} 3051, 2572, 1680, 1603, 1583, 1454, 1322 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 1.58 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 6.58 (d, 1H, J=4 Hz, H-7), 6.72 (dd, 1H, J=4, 8 Hz, H-6), 7.62–7.81 (m, $11H_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 61.4 (7-C), 64.6 (6-C), 118.5 (C-2), 127.0, 127.6, 128.4, 129.2, 129.8, 130.6, 131.2, 132.0 (2×Ph), 150.1 (3-C), 159.7 (SC=N), 172.0 (C=O). Mass (*m*/*z*): 326 (M^+). Anal. Calcd for $C_{17}H_{14}N_2OS_2$: C, 62.55; H, 4.32; N, 8.58%. Found: C, 62.20; H, 4.52; N, 8.35%.

4.3.11. Compound 6k. Yellowish needles (2.77 g, 77%), mp 118–120 °C. IR (KBr) ν_{max} 3059, 2566, 1682, 1601, 1580, 1448, 1317 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 1.62 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 6.62 (d, 1H, J=4 Hz, H-7), 6.76 (dd, 1H, J=4, 8 Hz, H-6), 7.12–7.83 (m, $10H_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 61.6 (7-C), 64.8 (6-C), 118.6 (C-2), 127.2, 128.0, 128.7, 129.4, 130.2, 131.0, 131.7, 132.4 (Ph, 4-ClC_6H_4), 150.3 (3-C), 159.8 (SC=N), 172.2 (C=O). Mass (*m*/*z*): 360 (M^+). Anal. Calcd for $C_{17}H_{13}ClN_2OS_2$: C, 56.58; H, 3.63; N, 7.76%. Found: C, 56.88; H, 3.87; N, 7.54%.

4.3.12. Compound 6l. Yellowish needles (2.81 g, 79%), mp 180–181 °C. IR (KBr) ν_{max} 3066, 2592, 1685, 1605, 1574, 1460, 1323 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 1.61 (d, 1H, J=8 Hz, SH, exchanges with D_2O), 3.74 (s, 3H, OMe), 6.60 (d, 1H, J=4 Hz, H-7), 6.74 (dd, 1H, J=4, 8 Hz, H-6), 7.10–7.95 (m, $10H_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 54.2 (OMe), 61.7 (7-C), 64.9 (6-C), 118.8 (2-C), 127.3, 128.0, 128.6, 129.5, 130.2, 131.0, 131.8, 132.6 (Ph, 4-$MeOC_6H_4$), 150.3 (3-C), 159.9 (SC=N), 172.0 (C=O). Mass (*m*/*z*): 356 (M^+). Anal. Calcd for $C_{18}H_{16}N_2O_2S_2$: C, 60.65; H, 4.52; N, 7.86%. Found: C, 60.30; H, 4.75; N, 7.66%.

4.4. Isolation of 4a, 4h and 4k and their conversion into the corresponding annulated products 6a, 6h and 6k

The procedure followed was the same as described above for the synthesis of **6** except that the time of MW irradiation in this case was 4 min instead of 8–12 min for **6**. The adducts **4** were recrystallised from ethanol to give a diastereomeric mixture (>96:<4; in the crude isolates the ratio was >94:<6 as determined by ^1H NMR spectroscopy) which

was again recrystallised from ethanol to obtain an analytical sample of **4a**, **4h** and **4k**. The adducts **4a**, **4h** and **4k** were assigned the *erythro* (*syn*) stereochemistry, as their ^{1}H NMR spectra exhibited lower values of coupling constant $J_{SCH,NCH}$=4 Hz, than that of the very minor (<4%) diastereomer (*threo* or *anti*), $J_{SCH,NCH}$=9 Hz.[18,34–38] Finely powdered intermediate compounds **4a**, **4h** and **4k** were intermittently MW irradiated for 6 min in the same way as described for the synthesis of **6** to give the corresponding annulated products **6a**, **6h** and **6k** quantitatively.

4.4.1. Compound 4a. Yellowish needles (2.13 g, 48%), mp 225–226 °C. IR (KBr) ν_{max} 3309, 2972, 1778, 1605, 1574, 1460, 1318 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 2.33 (s, 3H, Me), 6.68 (d, 1H, J=4 Hz, NCH), 6.79 (d, 1H, J=4 Hz, SCH), 7.65–7.86 (m, 15H$_{arom}$), 8.56 (br s, 1H, NH, exchanges with D_2O). ^{13}C NMR (DMSO-d_6/TMS) δ: 20.2 (Me), 64.5 (Ar–*C*), 69.4 (O=C–*C*), 127.0, 127.8, 128.5, 129.2, 129.9, 130.6, 131.2, 132.0, 132.7, 133.3, 134.0, 134.8 (3×Ph), 159.5 (SC=N), 161.2 (R–*C*), 172.1 (C=O). Mass (*m*/*z*): 443 (M^+). Anal. Calcd for $C_{25}H_{21}N_3O_3S$: C, 67.70; H, 4.77; N, 9.47%. Found: C, 67.36; H, 4.52; N, 9.72%.

4.4.2. Compound 4h. Yellowish needles (2.52 g, 51%), mp 218–220 °C. IR (KBr) ν_{max} 3307, 2970, 1775, 1603, 1586, 1458, 1315 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 2.35 (s, 3H, Me), 6.69 (d, 1H, J=4 Hz, NCH), 6.78 (d, 1H, J=4 Hz, SCH), 7.66–7.85 (m, 14H$_{arom}$), 8.57 (br s, 1H, NH, exchanges with D_2O). ^{13}C NMR (DMSO-d_6/TMS) δ: 20.3 (Me), 64.6 (Ar–*C*), 69.5 (O=C–*C*), 127.2, 127.8, 128.6, 129.2, 129.9, 130.6, 131.2, 131.8, 132.4, 133.0, 133.7, 134.3 (2×Ph, 4-ClC_6H_4), 150.1 (R–*C*), 159.6 (SC=N), 172.2 (C=O). Mass (*m*/*z*): 495 (M^+). Anal. Calcd for $C_{25}H_{20}ClN_3O_2S_2$: C, 60.78; H, 4.08; N, 8.51%. Found: C, 60.43; H, 4.33; N, 8.75%.

4.4.3. Compound 4k. Yellowish needles (2.07 g, 43%), mp 115–116 °C. IR (KBr) ν_{max} 3303, 2971, 1776, 1601, 1585, 1440, 1310 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 2.34 (s, 3H, Me), 6.67 (d, 1H, J=4 Hz, NCH), 6.77 (d, 1H, J=4 Hz, SCH), 7.64–7.84 (m, 15H$_{arom}$), 8.47 (br s, 1H, NH, exchanges with D_2O). ^{13}C NMR (DMSO-d_6/TMS) δ: 20.2 (Me), 64.5 (Ar–*C*), 69.5 (O=C–*C*), 118.2 (SCH), 127.1, 127.8, 128.4, 129.0, 129.7, 130.4, 131.0, 131.7, 132.3, 133.0, 133.7, 134.5 (2×Ph, 4-ClC_6H_4), 150.0 (Ph–*C*), 159.5 (SC=N), 172.3 (C=O). Mass (*m*/*z*): 482 (M^+). Anal. Calcd for $C_{25}H_{21}ClN_2O_2S_2$: C, 62.42; H, 4.40; N, 5.82%. Found: C, 62.77; H, 4.17; N, 5.60%.

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References and notes

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