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Tetrahedron
Tetrahedron 61 (2005) 10013–10017

Mercaptoacetic acid based expeditious synthesis of polyfunctionalised 1,3-thiazines

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Received 30 May 2005; revised 18 July 2005; accepted 4 August 2005

Available online 24 August 2005

Abstract—A novel three-component expeditious synthesis of 3,6-diaryl-5-mercaptoperhydro-2-thioxo-1,3-thiazin-5-ones from 2-methyl-2-phenyl-1,3-oxathiolan-5-one, an aromatic aldehyde and an *N*-aryldithiocarbamic acid is reported. The synthesis is diastereoselective and involves tandem Knoevenagel, Michael and ring transformation reactions under solvent-free microwave irradiation in a one-pot procedure.

1. Introduction

In general, polyfunctionalised heterocycles are interesting as potential biodegradable pharmaceuticals and agrochemicals.[1–3] 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 function in heterocycles, nucleosides, or nucleotides has led to a number of analogues possessing interesting biological and therapeutic properties.[4–11] The 1,3-thiazine nucleus is the active core of cephalosporins, which are among the most widely used β-lactam antibiotics. Owing to their chemical and biological interest, syntheses of various 1,3-thiazine derivatives have been reported in the literature[12–19] but 1,3-thiazine derivatives incorporating a thiol function are hitherto unreported and are not accessible through any one of the known synthetic routes for 1,3-thiazines[12–19] although they appear to be attractive scaffolds to be utilized for exploiting chemical diversity.

We have previously reported diastereoselective synthetic protocols for various highly functionalised 1,3-thiazines incorporating an amino, or acylamino function at C-5 employing glycine derivatives.[20–23] In a recent letter[24] we have reported a diastereoselective synthesis of 5-acylamino-3,6-diarylperhydro-2-thioxo-1,3-thiazin-4-ones via a multi-step one-pot reaction sequence starting from *N*-acylglycines, aromatic aldehydes and ammonium *N*-aryldithiocarbamates employing microwave (MW) irradiation.

As part of an ongoing programme of research, we had to develop a rapid and efficient synthesis of polyfunctionalised 1,3-thiazines **4** incorporating a thiol function at C-5. Thus, we devised a new mercaptoacetyl transfer agent, 2-methyl-2-phenyl-1,3-oxathiolan-5-one **1**, which leads to heterocyclisation and is the key element in the present successful synthetic strategy for the target compounds **4** (Scheme 1).

In view of achieving our goal expeditiously, we relied upon the significant advantages of multi-component reactions (MCRs)[25–29] under solvent-free MW irradiation.[30–34] Interestingly, the MCRs reported herein, yielding 5-mercapto-1,3-thiazines **4** from 1,3-oxathiolan-5-one **1** diastereoselectively (Scheme 1), 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 three-component synthesis (Scheme 1) was successful with an intimate mixture of 2-methyl-2-phenyl-1,3-oxathiolan-5-one **1**, an aromatic aldehyde **2** and an *N*-aryl dithiocarbamic acid **3** under intermittent MW irradiation of 480 W for the time specified in Table 1. Isolation and purification by recrystallisation from ethanol afforded the 1,3-thiazines **4** in 76–90% yield (Table 1) with >96% diastereoselectivity.

For comparison purposes, the final temperature of the reaction mixture was recorded immediately after the MW irradiation and found to be <85 °C. The reactions were also carried out using a thermostated oil bath at the same

Keywords: Solvent-free; Multi-component reactions; Microwaves; Stereoselective synthesis; 1,3-Thiazines.
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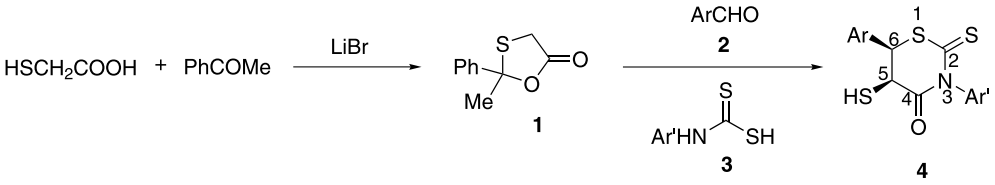
doi:10.1016/j.tet.2005.08.021



4, 6,7	Ar	Ar'	4,6,7	Ar	Ar'
a	Ph	Ph	**f**	4-$MeOC_6H_4$	2-MeC_6H_4
b	4-ClC_6H_4	Ph	**g**	Ph	4-$MeOC_6H_4$
c	4-$MeOC_6H_4$	Ph	**h**	4-ClC_6H_4	4-$MeOC_6H_4$
d	Ph	2-MeC_6H_4	**i**	4-$MeOC_6H_4$	4-$MeOC_6H_4$
e	4-ClC_6H_4	2-MeC_6H_4			

Scheme 1.

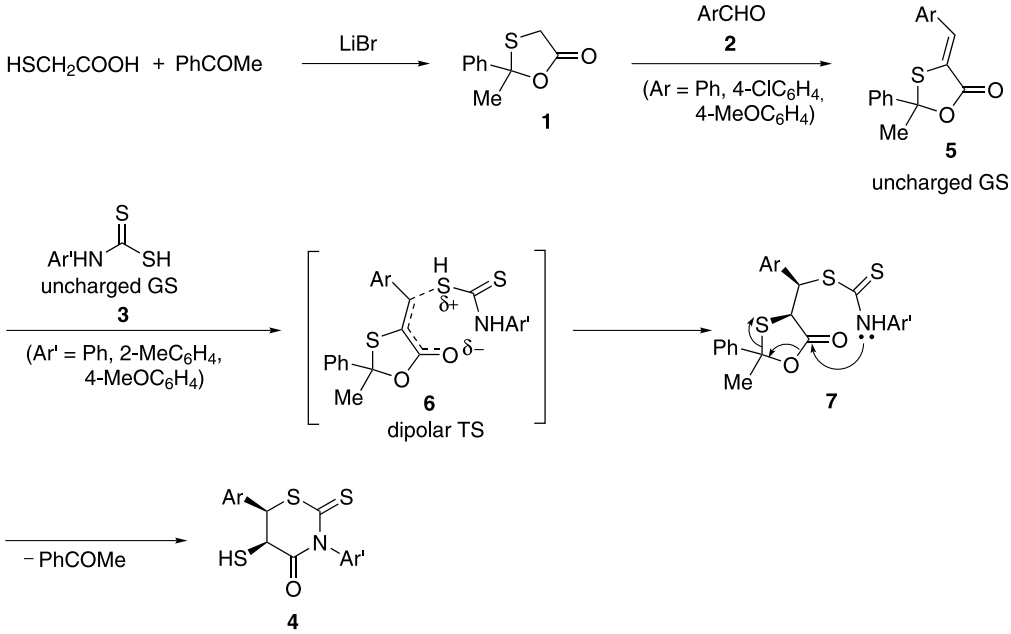
temperature (85 °C) as for the MW-activated method but for a longer (optimized) period of time (Table 1) to ascertain whether the MW method improves the yield or simply increases conversion rates. It was found that significantly lower yields (42–54%) were obtained using oil-bath heating rather than the MW-activated method (Table 1). This observation may be rationalized on the basis of the formation of a dipolar transition state (TS) from an uncharged ground state (GS) in these reactions (as an example, Scheme 2 shows a dipolar TS **6**), 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.[30]

The formation of 1,3-thiazines **4** is best explained by Michael type addition of *N*-aryldithiocarbamic acid **3** to 4-arylidene-1,3-oxathiolan-5-one **5**, generated in situ, to

Table 1. Solvent-free three-component synthesis of products **7** and **4**

Product	Time		Yield (%)[a]	
	MW (min)[b]	Thermal (h)[c]	MW	Thermal
7a	6	2	48	40
7d	4	1	51	45
7h	4	1	55	48
4a	10	4	79	43
4b	8	4	83	45
4c	10	5	80	47
4d	8	3	84	49
4e	8	3	90	54
4f	10	5	76	42
4g	10	4	81	46
4h	8	3	90	52
7i	10	5	78	44

[a] Yield of isolated and purified product.
[b] Microwave irradiation power=480 W.
[c] Oil-bath heating at 85 °C.



Scheme 2.

afford the corresponding Michael adducts **7**, which undergo ring transformation to yield the final products **4** (Scheme 2). This conclusion is based on the observation that the representative intermediate compounds **7a**, **7d** and **7h** could be isolated in 48–55% yields, and that these could be converted into the corresponding 1,3-thiazines **4a**, **4d** and **4h** in quantitative yield.

The formation of Michael adducts **7** and their ring transformation to **4** 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 in the case of MW activation was found to be $>96:<4$ and that from the oil-bath heating was $>55:<45$ as determined by ^{1}H NMR spectroscopy. The high diastereoselectivity ($>96\%$) in favour of *cis* isomers under MW irradiation may be explained by considering that MW irradiation favours the reactions occurring via a more polar TS,[30] and that the TS leading to the formation of *cis* isomers is more polar than that leading to the *trans* isomers because, in general, *cis* isomers are more polar than the *trans*.

3. Conclusion

In summary, we have developed a novel three-component one-pot mercaptoacetic acid-based synthetic protocol for an expeditious diastereoselective synthesis of potentially pharmaceutically and agrochemically useful polyfunctionalised 1,3-thiazines starting from readily and widely available simple substrates employing solvent-free microwave irradiation.

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 chemical laboratory microwave oven operating at 2450 MHz was used at an output of 480 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.

4.1.1. 2-Methyl-2-phenyl-1,3-oxathiolan-5-one 1. A mixture of acetophenone (3.5 mL, 30 mmol), mercaptoacetic acid (2.1 mL, 30 mmol) and a catalytic amount of lithium bromide (2.61 g, 3 mmol) was stirred for 2 h at 70 °C and kept overnight at room temperature. Water (50 mL) was added to the reaction mixture and the product thus, obtained was recrystallized from water to give an analytically pure sample of **1** as white needles. Yield 4.77 g, 82%, mp 121–122 °C. IR (KBr) ν_{max} 3008, 2970, 1774, 1596, 1510, 1446, 1020 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.98 (s, 3H, Me), 3.60 (d, 1H, $J=16.4$ Hz, CH_2), 3.69 (d, 1H, $J=16.4$ Hz, CH_2), 7.21–7.36 (m, 5H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 17.4 (CH_2), 34.8 (2-C), 87.3 (4-C), 127.5, 128.9, 129.7, 136.2 (Ph), 173.4 (C=O). Mass (*m*/*z*): 194 (M^+). Anal. Calcd for $C_{10}H_{10}O_2S$: C, 61.83; H, 5.19%. Found: C, 61.53; H, 5.38%.

4.2. 3,6-Diaryl-5-mercaptoperhydro-2-thioxo-1,3-thiazin-4-ones 4. General procedure

Thoroughly mixed 2-methyl-2-phenyl-1,3-oxathiolan-5-one **1** (10.0 mmol), an aromatic aldehyde **2** (10.0 mmol) and an *N*-aryldithiocarbamic acid **3** (10.0 mmol) were taken in a 20 mL vial and subjected to MW irradiation at 480 W for 2 min. The reaction mixture was then thoroughly mixed outside the microwave 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 solid thus, obtained was washed with water to give the crude product, which was recrystallized from ethanol to afford a diastereomeric mixture ($>96:<4$; in the crude products the ratio was $>95:<5$ as determined by ^{1}H NMR spectroscopy). The product on second recrystallisation from ethanol furnished an analytically pure sample of a single diastereomer **4** (Table 1). On the basis of ^{1}H NMR spectra and literature precedent,[35–40] the *cis* stereochemistry was assigned to **4**, as the coupling constant ($J_{5,6}=5$ Hz) for **4** was lower than that for the very minor ($<4\%$) diastereomer (*trans*), $J_{5,6}=10$ Hz.

4.2.1. Compound 4a. Yellowish needles (2.61 g, 79%), mp 138–139 °C. IR (KBr) ν_{max} 3012, 2555, 1685, 1601, 1575, 1450, 1055 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.59 (d, 1H, $J=8$ Hz, SH), 6.60 (d, 1H, $J=5$ Hz, 6-H), 6.74 (dd, 1H, $J=5$, 8 Hz, 5-H), 7.10–7.96 (m, 10H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 25.8 (5-C), 42.4 (6-C), 127.0, 127.7, 128.6, 129.9, 130.7, 132.1, 132.8, 133.9 (2×Ph), 165.4 (C=O), 192.1 (C=S). Mass (*m*/*z*): 331 (M^+). Anal. Calcd for $C_{16}H_{13}NOS_3$: C, 57.97; H, 3.95; N, 4.23%. Found: C, 57.63; H, 4.20; N, 4.03%.

4.2.2. Compound 4b. Yellowish needles (3.03 g, 83%), mp 137–138 °C. IR (KBr) ν_{max} 3012, 2555, 1685, 1601, 1575, 1450, 1095 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.59 (d, 1H, $J=8$ Hz, SH), 6.60 (d, 1H, $J=5$ Hz, 6-H), 6.74 (dd, 1H, $J=5$, 8 Hz, 5-H), 7.10–7.96 (m, 9H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 26.3 (5-C), 42.9 (6-C), 127.1, 128.7, 129.3, 130.5, 131.5, 132.6, 133.6, 134.5 (Ph, 4-ClC_6H_4), 165.5 (C=O), 192.4 (C=S). Mass (*m*/*z*): 365 (M^+). Anal. Calcd for $C_{16}H_{12}ClNOS_3$: C, 52.52; H, 3.31; N, 3.83%. Found: C, 52.49; H, 3.07; N, 4.01%.

4.2.3. Compound 4c. Yellowish needles (2.89 g, 80%), mp 132–133 °C. IR (KBr) ν_{max} 3020, 2598, 1687, 1605, 1582, 1453, 1090 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.60 (d, 1H, $J=8$ Hz, SH), 3.74 (s, 3H, OMe), 6.59 (d, 1H, $J=5$ Hz, 6-H), 6.72 (dd, 1H, $J=5$, 8 Hz, 5-H), 7.11–7.97 (m, 9H$_{arom}$).

^{13}C NMR (DMSO-d_6/TMS) δ: 26.1 (5-C), 42.7 (6-C), 54.7 (OMe), 127.2, 128.5, 129.4, 130.3, 131.2, 132.4, 133.3, 134.4 (Ph, 4-MeOC_6H_4), 165.4 (C=O), 192.2 (C=S). Mass (*m/z*): 361 (M^+). Anal. Calcd for $C_{17}H_{15}NO_2S_3$: C, 56.48; H, 4.18; N, 3.87%. Found: C, 56.14; H, 4.38; N, 3.65%.

4.2.4. Compound 4d. Yellowish needles (3.07 g, 84%), mp 139–140 °C. IR (KBr) ν_{max} 3018, 2561, 1682, 1602, 1579, 1448, 1092 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.58 (d, 1H, J=8 Hz, SH), 2.30 (s, 3H, Me), 6.58 (d, 1H, J=5 Hz, 6-H), 6.70 (dd, 1H, J=5, 8 Hz, 5-H), 7.09–7.95 (m, 9H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 20.2 (Me), 25.9 (5-C), 42.3 (6-C), 126.8, 127.5, 128.5, 129.2, 130.4, 131.3, 132.0, 132.6, 133.4, 134.0 (Ph, 2-MeC_6H_4), 165.3 (C=O), 192.1 (C=S). Mass (*m/z*): 345 (M^+). Anal. Calcd for $C_{17}H_{15}NOS_3$: C, 59.10; H, 4.38; N, 4.05%. Found: C, 58.75; H, 4.57; N, 3.80%.

4.2.5. Compound 4e. Yellowish needles (3.41 g, 90%), mp 143–144 °C. IR (KBr) ν_{max} 3022, 2590, 1683, 1604, 1568, 1452, 1091 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.61 (d, 1H, J=8 Hz, SH), 2.33 (s, 3H, Me), 6.63 (d, 1H, J=5 Hz, 6-H), 6.74 (dd, 1H, J=5, 8 Hz, 5-H), 7.12–8.01 (m, 8H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 20.8 (Me), 26.2 (5-C), 42.8 (6-C), 126.8, 127.6, 128.7, 129.4, 130.2, 131.3, 132.1, 132.7, 133.3, 134.1 (4-ClC_6H_4, 2-MeC_6H_4), 165.4 (C=O), 192.2 (C=S). Mass (*m/z*): 379 (M^+). Anal. Calcd for $C_{17}H_{14}ClNOS_3$: C, 53.74; H, 3.71; N, 3.69%. Found: C, 53.95; H, 3.55; N, 3.43%.

4.2.6. Compound 4f. Yellowish needles (2.85 g, 76%), mp 147–148 °C. IR (KBr) ν_{max} 3017, 2581, 1682, 1603, 1585, 1455, 1093 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.60 (d, 1H, J=8 Hz, SH), 2.31 (s, 3H, Me), 3.76 (s, 3H, OMe), 6.61 (d, 1H, J=5 Hz, 6-H), 6.72 (dd, 1H, J=5, 8 Hz, 5-H), 7.13–7.98 (m, 8H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 21.0 (Me), 26.1 (5-C), 42.6 (6-C), 55.1 (OMe), 126.9, 127.5, 128.9, 129.5, 130.1, 130.8, 131.6, 132.3, 132.9, 133.8 (4-MeOC_6H_4, 2-MeC_6H_4), 165.5 (C=O), 192.0 (C=S). Mass (*m/z*): 375 (M^+). Anal. Calcd for $C_{18}H_{17}NO_2S_3$: C, 57.57; H, 4.56; N, 3.73%. Found: C, 57.27; H, 4.36; N, 3.97%.

4.2.7. Compound 4g. Yellowish needles (2.92 g, 81%), mp 140–141 °C. IR (KBr) ν_{max} 3011, 2552, 1687, 1598, 1579, 1453, 1105 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.59 (d, 1H, J=8 Hz, SH), 3.72 (s, 3H, OMe), 6.61 (d, 1H, J=5 Hz, 6-H), 6.73 (dd, 1H, J=5, 8 Hz, 5-H), 7.11–7.98 (m, 9H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 25.9 (5-C), 42.4 (6-C), 54.8 (OMe), 127.2, 128.7, 129.3, 130.4, 131.4, 132.2, 133.4, 134.3 (Ph, 4-MeOC_6H_4), 165.7 (C=O), 192.5 (C=S). Mass (*m/z*): 361 (M^+). Anal. Calcd for $C_{17}H_{15}NO_2S_3$: C, 56.48; H, 4.18; N, 3.87%. Found: C, 56.73; H, 4.38; N, 3.52%.

4.2.8. Compound 4h. Yellowish needles (3.56 g, 90%), mp 163–165 °C. IR (KBr) ν_{max} 3019, 2596, 1687, 1601, 1581, 1452, 1123 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.62 (d, 1H, J=8 Hz, SH), 3.74 (s, 3H, OMe), 6.63 (d, 1H, J=5 Hz, 6-H), 6.73 (dd, 1H, J=5, 8 Hz, 5-H), 7.13–7.98 (m, 8H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 26.5 (5-C), 42.9 (6-C), 55.5 (OMe), 127.2, 128.8, 129.4, 131.3, 132.0, 132.8, 133.6, 134.4 (4-MeOC_6H_4, 4-ClC_6H_4), 165.9 (C=O), 192.6 (C=S). Mass (*m/z*): 395 (M^+). Anal. Calcd for $C_{17}H_{14}ClNO_2S_3$: C, 51.57; H, 3.56; N, 3.54%. Found: C, 51.21; H, 3.77; N, 3.35%.

4.2.9. Compound 4i. Yellowish needles (3.05 g, 78%), mp 155–156 °C. IR (KBr) ν_{max} 3013, 2592, 1685, 1603, 1586, 1458, 1118 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 1.61 (d, 1H, J=8 Hz, SH), 3.73 (s, 3H, OMe), 3.79 (s, 3H, OMe), 6.62 (d, 1H, J=5 Hz, 6-H), 6.72 (dd, 1H, J=5, 8 Hz, 5-H), 7.12–7.97 (m, 8H$_{arom}$). ^{13}C NMR (DMSO-d_6/TMS) δ: 26.4 (5-C), 42.8 (6-C), 55.0, 55.4 (2×OMe), 127.3, 128.7, 129.5, 131.4, 132.1, 132.9, 133.6, 134.6 (2×4-MeOC_6H_4), 165.8 (C=O), 192.5 (C=S). Mass (*m/z*): 391 (M^+). Anal. Calcd for $C_{18}H_{17}NO_3S_3$: C, 55.22; H, 4.38; N, 3.58%. Found: C, 54.93; H, 4.58; N, 3.22%.

4.3. Isolation of the Michael adducts 7a, 7d and 7h and their conversion into the corresponding final products 4a, 4d and 4h

The procedure followed was the same as described above for the synthesis of **4** except that the time of MW irradiation in this case was 4–6 min instead of 8–10 min for **4**. The adducts **7** were recrystallized from ethanol to give a diastereomeric mixture (>97:<3; in the crude isolates the ratio was >94:<6 as determined by ^{1}H NMR spectroscopy), which was again recrystallized from ethanol to obtain an analytically pure sample of **7a**, **7d** and **7h**. The adducts **7a**, **7d** and **7h** were assigned the *erythro* stereochemistry, as their ^{1}H NMR spectra exhibited lower values of coupling constant, $J_{cyclicSCH,\ acyclicSCH}$=5 Hz, than that of the very minor (<3%) diastereomer (*threo*), $J_{cyclicSCH,\ acyclicSCH}$=10 Hz.[35–40] Finely powdered intermediate compounds **7a**, **7d** and **7h** were intermittently MW irradiated for 6 min in the same way as described for the synthesis of **4** to give the corresponding annulated products **4a**, **4d** and **4h** quantitatively.

4.3.1. Compound 7a. Yellowish needles (2.16 g, 48%), mp 127–128 °C. IR (KBr) ν_{max} 3148, 3008, 2971, 1776, 1604, 1574, 1455, 1108, 1020 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 2.34 (s, 3H, Me), 6.64 (d, 1H, J=5 Hz, acyclic SCH), 6.77 (d, 1H, J=5 Hz, cyclic SCH), 7.14–8.00 (m, 15H$_{arom}$), 9.38 (br s, 1H, NH, exchanges with D_2O). ^{13}C NMR (DMSO-d_6/TMS) δ: 17.4 (Me), 35.0 (Me-*C*), 42.5 (Ar-*C*), 87.5 (O=C–*C*), 127.2, 128.6, 129.5, 130.6, 131.5, 132.7, 133.6, 134.5 (2×Ph), 173.7 (C=O), 192.3 (C=S). Mass (*m/z*): 451 (M^+). Anal. Calcd for $C_{24}H_{21}NO_2S_3$: C, 63.83; H, 4.69; N, 3.10%. Found: C, 63.53; H, 4.45; N, 3.35%.

4.3.2. Compound 7d. Yellowish needles (2.37 g, 51%), mp 128–129 °C. IR (KBr) ν_{max} 3147, 3010, 2970, 1775, 1603, 1579, 1460, 1109, 1021 cm^{-1}. ^{1}H NMR (DMSO-d_6/TMS) δ: 2.31 (s, 3H, Me), 2.34 (s, 3H, Me), 6.63 (d, 1H, J=5 Hz, acyclic SCH), 6.76 (d, 1H, J=5 Hz, cyclic SCH), 7.14–7.98 (m, 14H$_{arom}$), 9.36 (br s, 1H, NH, exchanges with D_2O). ^{13}C NMR (DMSO-d_6/TMS) δ: 17.3 (Me), 20.3 (Me), 34.9 (Me-*C*), 42.4 (Ar-*C*), 87.3 (O=C–*C*), 126.9, 127.6, 128.7, 129.2, 130.3, 131.4, 132.1, 132.7, 133.4, 134.1 (Ph, 2-Me C_6H_4), 173.6 (C=O), 192.1 (C=S). Mass (*m/z*): 465 (M^+). Anal. Calcd for $C_{25}H_{23}NO_2S_3$: C, 64.48; H, 4.98; N, 3.10%. Found: C, 64.14; H, 4.73; N, 3.37%.

4.3.3. Compound 7h. Yellowish needles (2.84 g, 55%), mp

142–143 °C. IR (KBr) ν_{max} 3150, 3012, 2973, 1779, 1605, 1580, 1459, 1112, 1023 cm^{-1}. ^1H NMR (DMSO-d_6/TMS) δ: 2.33 (s, 3H, Me), 3.72 (s, 3H, Me), 6.65 (d, 1H, $J=5$ Hz, acyclic SCH), 6.78 (d, 1H, $J=5$ Hz, cyclic SCH), 7.13–8.01 (m, $13H_{arom}$), 9.39 (br s, 1H, NH, exchanges with D_2O). ^{13}C NMR (DMSO-d_6/TMS) δ: 17.5 (Me), 35.1 (Me-*C*), 42.8 (Ar-*C*), 55.6 (OMe), 87.6 (O=C–*C*), 127.4, 128.7, 129.6, 131.4, 132.2, 133.0, 133.6, 134.7 (4-ClC_6H_4, 4-$MeoC_6H_4$), 173.8 (C=O), 192.5 (C=S). Mass (*m/z*): 516 (M^+). Anal. Calcd for $C_{25}H_{22}ClNO_3S_3$: C, 58.18; H, 4.30; N, 2.71%. Found: C, 57.85; H, 4.05; N, 2.91%.

Acknowledgements

We sincerely thank SAIF, Punjab University, Chandigarh for providing microanalyses and spectra.

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