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A novel multicomponent approach to the synthesis of 1,3-thiazolidine-2-thiones

Abdolali Alizadeh *, Nasrin Zohreh, Hamideh Sabahnoo, Zohreh Noaparast

Department of Chemistry, Tarbiat Modares University, P.O. Box 14115-175, Tehran, Iran

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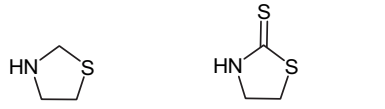
ABSTRACT

An easy, efficient, and simple one-pot approach for the synthesis of 1,3-thiazolidine-2-thiones via multicomponent reaction is reported. The reaction of a primary amine with carbon disulfide in the presence of dibenzoylacetylene or bis(4-methyl-1-benzoyl)acetylene in a mixture of CH_2Cl_2 and H_2O after 5 h, afforded the title compound as alkene diastereomers.

1. Introduction

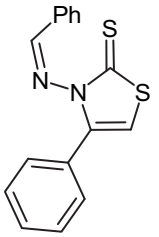
During the past decade, combinatorial chemistry has provided access to chemical libraries based on privileged structures,[1] with heterocyclic structures receiving special attention as they belong to a class of compounds with proven utility in medicinal chemistry.[2] There are numerous biologically active molecules with five-membered rings, containing two heteroatoms. Thiazolidine **1** and its derivatives are important scaffolds for drug candidates. Anticonvulsant, sedative, antidepressant, anti-inflammatory, antihypertensive, antihistaminic, and antiarthritic activities are a few among many other biological responses shown by this scaffold (Fig. 1).[3]



1 (Thiazolidine) **2** (Thiazolidine-2-thione)

Fig. 1.

Compounds containing the 1,3-thiazolidine-2-thioneone **2** ring have showed a wide range of pharmacological activities. For example, Fezatione **3** is an antifungal and antitrichophytic (Fig. 2).[4] In addition, these compounds display a central role in modern synthetic organic chemistry.[5] Metal enolates of *N*-acyl-1,3-oxazolidine-2-tiones have been used as chiral auxiliaries for aldol type reactions with high diastereoselectivity.[6]



3: Fezatione

Fig. 2.

As part of our work devoted to the synthesis of important heterocycles especially heterocycles with two heteroatoms,[7] herein we report a novel, one-pot, three-component reaction for the synthesis of 1,3-thiazolidine-2-thiones.

2. Results and discussion

Our research group reported the synthesis of a novel series of heterocycles using the reaction of dibenzoylacetylene with various zwitterions and electrophiles[8] and recently the synthesis of biologically active rhodanines from the reaction of primary amines, carbon disulfide, and dialkyl acetylenedicarboxylates or fumaryl chloride were reported by our research group (Scheme 1).[9] Trapping of the amine–CS_2 zwitterion by dialkyl acetylenedicarboxylate, afforded only one of the two possible stereoisomers for all derivatives, however we were unable to identify the configuration of the alkenes.

* Corresponding author. Tel.: +98 21 8800663; fax: +98 21 88006544; e-mail address: aalizadeh@modares.ac.ir (A. Alizadeh).

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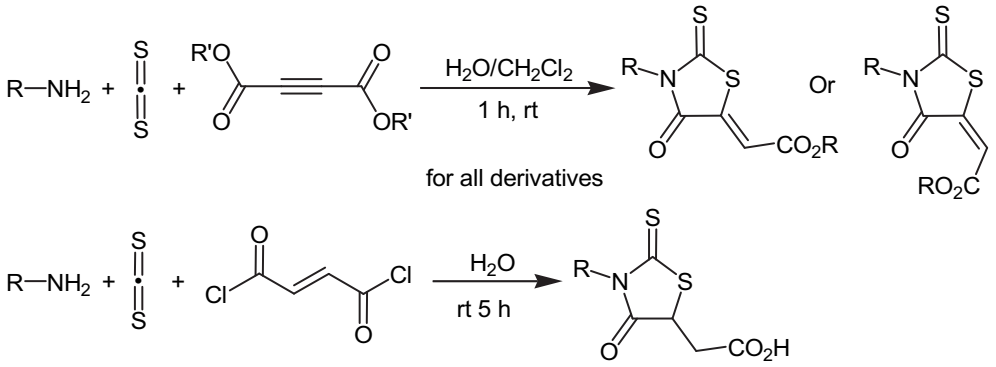
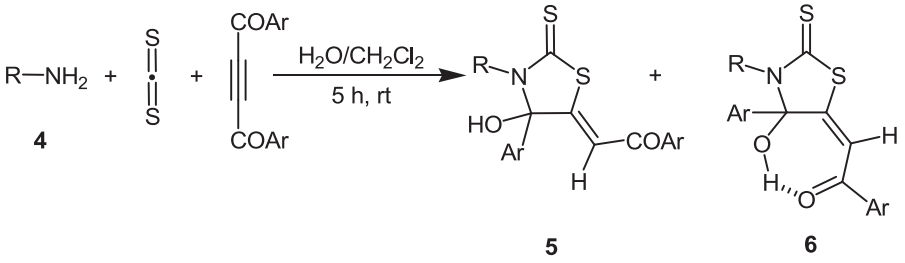


Scheme 1.

Along the same lines, we have become interested in application of dibenzoylacetylene or bis(4-methyl-1-benzoyl)acetylene instead of dialkyl acetylenedicarboxylates in this reaction for the synthesis of title compound. Our new synthetic route is given in Scheme 2. The reaction of primary amine **4**, CS_2 and dibenzoylacetylene or bis (4-methyl-1-benzoyl)acetylene proceeds in a mixture of CH_2Cl_2 and H_2O at room temperature to produce 2-(3-alkyl-4-hydroxy-4-aryl-2-thioxo-1,3-thiazolan-5-yliden)-1-aryl-1-ethanone derivatives **5**, **6** in total 76–97% yields (Scheme 2). As stated below, both of the *E* and *Z* setereoisomers were obtained from the reaction in all instances.



5 **6**

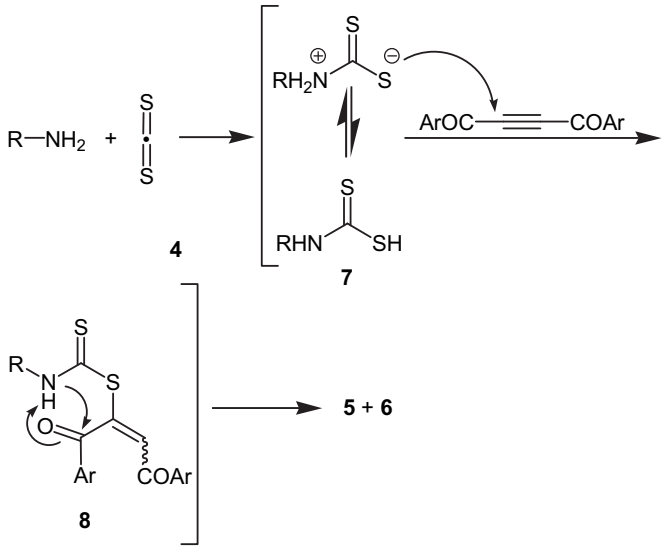
Entry	R	Ar	Ratio of **5**:**6**	Total Yield %
a	p-$MeC_6H_4CH_2$-	Ph	30:70	86
b	p-$ClC_6H_4CH_2$-	Ph	35:65	83
c	p-$MeOC_6H_4CH_2$-	Ph	26:74	84
d	$C_6H_5CH_2$-	Ph	32:68	76
e	$C_6H_5CH(Me)$-	Ph	8:48:44 (**9c**)	97
f	Me	Ph	71:29	93
g	n-Pr	Ph	16:84	82
h	i-Bu	Ph	45:55	85
i	p-$MeC_6H_4CH_2$-	p-MeC_6H_4-	30:70	90

Scheme 2.

The data obtained from elemental analysis, IR, and high-field ^1H and ^{13}C NMR spectra confirmed all products and stereoisomers. The mass spectrum of **5a** and **6a** showed no molecular ion peak at *m*/*z* 431; however, for other derivatives this peak was detected. The most important absorption band in IR spectrum of **5a** is due to the OH stretching frequency, that is, appeared as a broad band at 3275 cm^{-1}. Absorption bands at 1641 and 1595 cm^{-1} are due to the C=O and C=C groups. In the ^1H NMR spectrum of **5a**, two sharp singlet peaks at δ_H=2.26 and 7.02 ppm readily recognized as arising from methyl of amine and C=CH moiety. In ^1H NMR spectrum of **6a**, these two moieties are appearing at 2.30 and 5.81 ppm. Two hydrogens of CH_2N of **5a** are appeared as two separated diastereotopic doublets at δ_H=4.58 and 5.17 ppm ($^2J_{HH}$=14.9 Hz), whereas for **6a** appears as a doublet at 4.35 ppm with $^2J_{HH}$=6.0 Hz. The most important difference between ^1H NMR spectrum of **5a** and **6a** is due to the chemical shift of their OH group. Compound **5a** can not orient for an intramolecular hydrogen bonding and thus the OH signal appears as a broad band at 4.77 ppm while for **6a**, the intramolecular hydrogen bond result in the proton resonating down field at 11.08 ppm. The three phenyl moieties of both of **5a** and **6a** gave rise to characteristic signals in the corresponding aromatic region of the spectrum. The ^1H decoupled ^{13}C NMR spectrum of **5a** and **6a** showed 19 distinct signals in agreement with proposed structure. The carbon of C=CH of **5a** and **6a** resonances at 113.5 and 127.2 ppm are appeared, respectively.

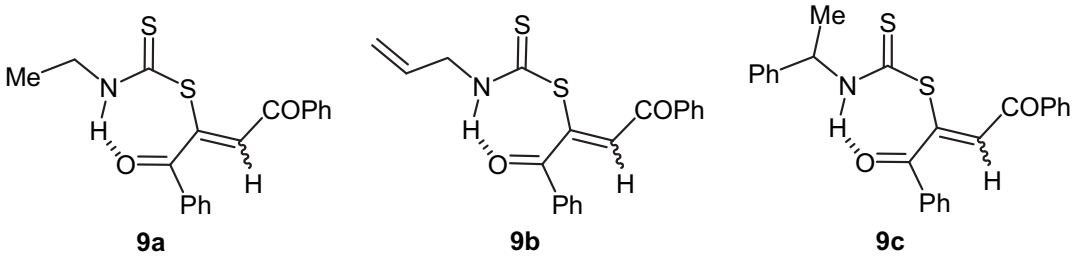
Although we have not established the mechanism of our reaction in an experimental manner, a possible explanation is proposed in Scheme 3. The reaction mechanism leading to product **5** and **6** presumably proceeds through an initial addition of the amine **4** to the carbon disulfide to afford zwitterion **7**.[10] Subsequently; intermediate **7** is trapped by bisaroylacetylene to produce intermediate **8**. Probably, the thiocarbamate **8** undergoes intramolecular cyclization to convert to the products **5** and **6** in 76–97% total yield. (It is important to note that the five-membered ring formation is kinetically more favorable than the six membered ring).[11]

When we used allyamine or ethylamine in the reaction, only the intermediate **8** (**9a**, **9b**) was obtained and product **5** or **6** wasn't



Scheme 3.

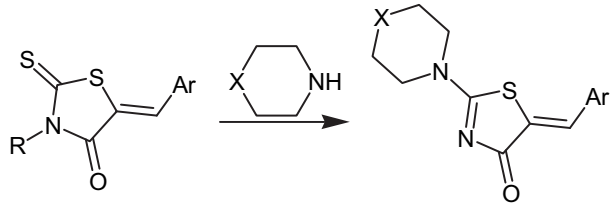
produced. The reaction with 1-phenyl-1-ethanamine produces **9c** in addition of two stereoisomers (**5e**, and **6e**) (Scheme 4).



Scheme 4.

3. Conclusion

In summery, in this paper we developed a novel method for the synthesis of 1,3-Thiazolidine-2-thiones of potential synthetic and pharmacological interest using the simple and inexpensive starting materials. For example, 2-amino-5-arylidene-1,3-thiazol-4(5*H*)-one can be obtained from the reaction between 5-arylidene-rhodanine and amine by sulfur/nitrogen displacement under solvent-free microwave irradiation (Scheme 5).[12] Compounds containing 2-amino-5-arylidene-1,3-thiazol-4(5*H*)-one moiety are reported to have antiviral,[13] antimicrobial,[14] cardiotonic,[15] and anti-inflammatory[16] effects.



Scheme 5.

The reaction is one pot and performed under neutral condition. The simplicity of the present procedure makes it an interesting alternative to the complex multistep approaches.

4. Experimental

4.1. General

FT-IR spectra were recorded as KBr pellets on a Shimadzu IR-460 spectrometer. ^{1}H NMR (500.13 MHz) and ^{13}C NMR (125.75 MHz) spectra were obtained using a Bruker DRX-500 AVANCE spectrometer. All NMR spectra were determined in $CDCl_3$ at ambient temperature. Melting points measured on an Electrothermal 9100 apparatus. Elemental analyses for C, H, and N performed using a Heraeus CHN–O–Rapid analyzer. Mass spectra were recorded on a FINNIGAN-MATT 8430 mass spectrometer operating at an ionization potential of 70 eV. All chemicals were purchased from Merck or Aldrich and were used without further purification. Dibenzoylacetylene, and bis(4-methyl-1-benzoyl)acetylene was prepared according to the literature procedure.[17,18]

4.2. General synthesis procedure: (for example, 5a)

To a magnetically stirred 5 mL flat bottom flask containing *p*-methylbenzylamine (0.12 g, 1 mmol) and H_2O (2 mL as solvent), was added CS_2 (0.15 g, 2 mmol). Then, a solution of dibenzoylacetylene (0.23 g, 1 mmol) in dichloromethane (3 mL) was added to the reaction mixture and was allowed to stir vigorously at room temperature for 5 h. After completion of the reaction (monitoring by TLC), the organic layer was extracted with CH_2Cl_2 (16 mL). The solvent was removed on a rotary evaporator and both of products were separated by silica gel (Merck 230–240 mesh) column chromatography using *n*-hexane–EtOAc (7:1).

*4.2.1. 2-[4-Hydroxy-3-(4-methylbenzyl)-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden]-1-phenyl-1-ethanone (**5a**).* Yellow powder, mp 188–190 °C, 0.11 g, yield: 26%. R_f (12% EtOAc/*n*-hexane): 0.23; IR (KBr) (ν_{max}, cm^{-1}): 3275 (OH), 1641 (C=O), 1595 (C=C), 1558 and 1463 (Ar), 1052 (C=S). Anal. Calcd for $C_{25}H_{21}NO_2S_2$ (431.56): C, 69.58; H, 4.90; N, 3.25%. Found: C, 69.63; H, 4.92; N, 3.27%. MS (EI, 70 eV): *m*/*z* (%)=429 (M^+–2, 5), 307 (23), 264 (29), 236 (17), 202 (31), 168 (51), 146 (44), 105 (78), 91 (69), 77 (83), 58 (56), 43 (100). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=2.26 (3H, s, Me), 4.58 (1H, d, $^2J_{HH}$=14.9 Hz, CH_2N), 4.77 (1H, br, OH), 5.17 (1H, d, $^2J_{HH}$=14.9 Hz, CH_2N), 6.95 (2H, d, $^3J_{HH}$=7.8 Hz, 2CH of Ar), 7.02 (1H, s, C=C*H*), 7.14 (2H, d, $^3J_{HH}$=7.9 Hz, 2CH of Ar), 7.27 (2H, d, $^3J_{HH}$=7.1 Hz, 2CH of Ar), 7.31–7.32 (3H, m, 3CH of Ar), 7.35 (1H, t, $^3J_{HH}$=7.2 Hz, CH of Ar), 7.47 (2H, t, $^3J_{HH}$=7.3 Hz, 2CH of Ar), 7.72 (2H, d, $^3J_{HH}$=7.4 Hz, 2CH of Ar). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=21.1 (CH_3), 48.7 (CH_2N), 102.2 (COH), 113.5 (C=*C*H), 125.5 (2CH of Ar), 128.4 (2CH of Ar), 128.6 (2CH of Ar), 128.8 (2CH of Ar), 128.8 (2CH of Ar), 128.9 (2CH of Ar), 129.4 (CH of Ar), 133.3 (CH of Ar), 133.4 (C_{ipso}–Me), 136.6 (C_{ipso}–COH), 137.0 (C_{ipso}–CH_2N), 138.9 (C_{ipso}–CO), 161.7 (*C*=CH), 188.6 (CO), 193.7 (CS).

*4.2.2. 2-[3-(4-Chlorobenzyl)-4-hydroxy-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden]-1-phenyl-1-ethanone (**5b**).* Pale yellow powder, mp 184–186 °C, 0.13 g, yield: 29%. R_f (12% EtOAc/*n*-hexane): 0.30; IR

(KBr) (ν_{max}, cm^{-1}): 3205 (OH), 1641 (C=O), 1620 (C=C), 1554 and 1442 (Ar), 1048 (C=S). Anal. Calcd for $C_{24}H_{18}ClNO_2S_2$ (451.98): C, 63.78; H, 4.01; N, 3.10%. Found: C, 63.81; H, 4.03; N, 3.13%. MS (EI, 70 eV): *m*/*z* (%)=451 (M^+, 5), 430 (9), 416 (17), 400 (37), 310 (18), 268 (7), 163 (18), 125 (44), 105 (100), 89 (6), 77 (91), 51 (19). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=3.61–4.42 (1H, br, OH), 4.84 (1H, d, $^2J_{HH}$=16.2 Hz, CH_2N), 5.31 (1H, d, $^2J_{HH}$=16.2 Hz, CH_2N), 7.06 (1H, s, C=C*H*), 7.10 (2H, d, $^3J_{HH}$=7.9 Hz, 2CH of Ar), 7.18 (1H, t, $^3J_{HH}$=6.30 Hz, CH of Ar), 7.28 (2H, t, $^3J_{HH}$=6.7 Hz, 2CH of Ar), 7.30 (2H, d, $^3J_{HH}$=6.5 Hz, 2CH of Ar), 7.32 (2H, d, $^3J_{HH}$=7.8 Hz, 2CH of Ar), 7.41 (1H, t, $^3J_{HH}$=7.3 Hz, CH of Ar), 7.50 (2H, t, $^3J_{HH}$=6.9 Hz, 2CH of Ar), 7.76 (2H, d, $^3J_{HH}$=7.4 Hz, 2CH of Ar). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C=45.8 (CH_2N), 101.9 (COH), 113.9 (C=*C*H), 125.5 (2CH of Ar), 126.5 (2CH of Ar), 128.3 (2CH of Ar), 128.4 (2CH of Ar), 128.7 (2CH of Ar), 128.8 (2CH of Ar), 128.8 (CH of Ar), 129.2 (CH of Ar), 132.5 (C_{ipso}–Cl), 136.5 (C_{ipso}–COH), 136.5 (C_{ipso}–CH_2N), 138.3 (C_{ipso}–CO), 161.3 (*C*=CH), 188.7 (CO), 194.1 (CS).

*4.2.3. 2-[4-Hydroxy-3-(4-methoxybenzyl)-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden]-1-phenyl-1-ethanone (**5c**).* Pale yellow powder, mp 179–181 °C, 0.10 g, yield: 22%. R_f (12% EtOAc/*n*-hexane): 0.28; IR (KBr) (ν_{max}, cm^{-1}): 3265 (OH), 1638 (C=O), 1610 (C=C), 1551 and 1459 (Ar), 1043 (C=S). Anal. Calcd for $C_{25}H_{21}NO_3S_2$ (447.56): C, 67.09; H, 4.73; N, 3.13%. Found: C, 67.14; H, 4.75; N, 3.14%. MS (EI, 70 eV): *m*/*z* (%)=355 (15), 307 (9), 264 (27), 250 (34), 183 (43), 167 (18), 146 (39), 105 (100), 91 (56), 77 (77), 57 (60), 43 (57). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=2.48–2.60 (1H, br, OH), 3.76 (3H, s, OMe), 4.38 (1H, d, $^2J_{HH}$=14.7 Hz, CH_2N), 5.28 (1H, d, $^2J_{HH}$=14.7 Hz, CH_2N), 6.73 (2H, d, $^3J_{HH}$=8.7 Hz, 2CH of Ar), 7.08 (1H, s, C=C*H*), 7.29 (1H, t, $^3J_{HH}$=7.1 Hz, 1CH of Ar), 7.36–7.39 (5H, m, 5CH of Ar), 7.40–7.42 (1H, m, CH of Ar), 7.46 (1H, t, $^3J_{HH}$=7.4 Hz, CH of Ar), 7.50–7.52 (2H, m, 2CH of Ar), 7.82 (2H, t, $^3J_{HH}$=7.3 Hz, 2CH of Ar). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=48.2 (CH_2N), 55.3 (OMe), 102.0 (COH), 113.4 (C=*C*H), 125.3 (2CH of Ar), 128.3 (2CH of Ar), 128.7 (2CH of Ar), 128.9 (2CH of Ar), 129.0 (2CH of Ar),129.6 (2CH of Ar), 130.3 (CH of Ar), 133.3 (CH of Ar), 134.1 (C_{ipso}–CH_2N), 136.5 (C_{ipso}–COH), 138.9 (C_{ipso}–CO), 154.9 (C_{ipso}–OMe), 161.1 (*C*=CH), 181.3 (CO), 188.2 (CS).

*4.2.4. 2-(3-Benzyl-4-hydroxy-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden)-1-phenyl-1-ethanone (**5d**).* Pale yellow powder, mp 195–197 °C, 0.11 g, yield: 25%. R_f (12% EtOAc/*n*-hexane): 0.27; IR (KBr) (ν_{max}, cm^{-1}): 3225 (OH), 1640 (C=O), 1596 (C=C), 1555 and 1447 (Ar), 1050 (C=S). Anal. Calcd for $C_{24}H_{19}NO_2S_2$ (417.54): C, 69.04; H, 4.59; N, 3.35%. Found: C, 69.03; H, 4.60; N, 3.33%. MS (EI, 70 eV): *m*/*z* (%)=417 (M^+, 8), 401 (5), 312 (10), 269 (31), 223 (12), 163 (84), 149 (37), 105 (91), 91 (100), 77 (68), 65 (19), 51 (22). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=4.21–4.33 (1H, br, OH), 4.67 (1H, d, $^2J_{HH}$=15 Hz, CH_2N), 5.20 (1H, d, $^2J_{HH}$=15 Hz, CH_2N), 7.01 (1H, s, C=C*H*), 7.12–7.17 (3H, m, 3CH of Ar), 7.23–7.32 (7H, m, 7CH of Ar), 7.37 (1H, t, $^3J_{HH}$=7.0 Hz, CH of Ar), 7.45–7.49 (2H, m, 2CH of Ar), 7.72 (2H, d, $^3J_{HH}$=7.4 Hz, 2CH of Ar). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C=48.8 (CH_2N), 102.1 (COH), 113.5 (C=*C*H), 125.5 (2CH of Ar), 127.0 (2CH of Ar), 128.1 (2CH of Ar), 128.3 (2CH of Ar), 128.5 (2CH of Ar), 128.7 (2CH of Ar), 129.0 (CH of Ar), 129.5 (CH of Ar), 133.3 (CH of Ar), 136. 5 (C_{ipso}–COH), 136.5 (C_{ipso}–CH_2N), 138.7 (C_{ipso}–CO), 161.5 (*C*=CH), 188.6 (CO), 193.9 (CS).

*4.2.5. 2-[4-Hydroxy-4-phenyl-3-(1-phenylethyl)-2-thioxo-1,3-thiazolan-5-yliden]-1-phenyl-1-ethanone (**5e**).* Pale yellow powder, mp 163–165 °C, 0.03 g, yield: 7%. R_f (12% EtOAc/*n*-hexane): 0.30; IR (KBr) (ν_{max}, cm^{-1}): 3220 (OH), 1636 (C=O), 1594 (C=C), 1529 and 1443 (Ar), 1056 (C=S). Anal. Calcd for $C_{25}H_{21}NO_2S_2$ (431.56): C, 69.58; H, 4.90; N, 3.25%. Found: C, 69.60; H, 4.95; N, 3.27%. MS (EI, 70 eV): *m*/*z* (%)=422 (6), 322 (10), 268 (43), 236 (29), 167 (17), 149 (51), 105 (100), 91 (38), 77 (71), 57 (44), 43 (41). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=1.74 (3H, d, $^3J_{HH}$=7.2 Hz, $CHCH_3$), 4.61 (1H, br, OH), 5.39 (1H, q, $^3J_{HH}$=7.2 Hz, *C*HCH_3), 6.96 (1H, s, C=C*H*), 7.13–7.23 (4H, m, 4CH of Ar), 7.32–7.39 (4H, m, 4CH of Ar), 7.43–7.49 (3H, m, 3CH of Ar), 7.52 (2H, t, $^3J_{HH}$=7.4 Hz, 2CH of Ar), 7.77 (2H, d, $^3J_{HH}$=8.1 Hz, 2CH of Ar). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=17.0 (CH*C*H$_3$), 57.0 (*C*HCH$_3$), 103.2 (COH), 113.0 (C=*C*H), 125.6 (2CH of Ar), 127.9 (2CH of Ar), 128.2 (2CH of Ar), 128.3 (2CH of Ar), 128.7 (2CH of Ar), 128.7 (2CH of Ar), 128.8 (CH of Ar), 133.2 (CH of Ar), 136.9 (C_{ipso}–COH), 138.7 (C_{ipso}–CHN), 138.9 (C_{ipso}–CO), 162.4 (*C*=CH), 188.5 (CO), 192.0 (CS).

*4.2.6. 2-(4-Hydroxy-3-methyl-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden)-1-phenyl-1-ethanone (**5f**).* Yellow oil, 0.22 g, yield: 66%. R_f (12% EtOAc/*n*-hexane): 0.22; IR (KBr) (ν_{max}, cm^{-1}): 3240 (OH), 1677 (C=O), 1596 (C=C), 1555 and 1447 (Ar), 1055 (C=S). Anal. Calcd for $C_{18}H_{15}NO_2S_2$ (341.44): C, 63.32; H, 4.43; N, 4.10%. Found: C, 63.36; H, 4.42; N, 4.13%. MS (EI, 70 eV): *m*/*z* (%)=341 (M^+, 43), 325 (7), 268 (26), 220 (6), 163 (100), 135 (10), 105 (93), 85 (28), 77 (81), 72 (66), 51 (26). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=3.09 (3H, s, NMe), 5.31–5.80 (1H, br, OH), 7.08 (1H, s, C=C*H*), 7.28 (2H, t, $^3J_{HH}$=7.5 Hz, 2CH of Ar), 7.34 (1H, t, $^3J_{HH}$=7.2 Hz, CH of Ar), 7.38 (1H, t, $^3J_{HH}$=7.4 Hz, CH of Ar), 7.41 (2H, t, $^3J_{HH}$=7.6 Hz, 2CH of Ar), 7.49 (2H, d, $^3J_{HH}$=7.6 Hz, 2CH of Ar), 7.74 (2H, d, $^3J_{HH}$=7.8 Hz, 2CH of Ar). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C=31.9 (NCH_3), 101.5 (COH), 113.9 (C=*C*H), 128.3 (2CH of Ar), 128.5 (2CH of Ar), 129.0 (2CH of Ar), 129.7 (2CH of Ar), 130.9 (CH of Ar), 133.4 (CH of Ar), 136.5 (C_{ipso}–OH), 138.7 (C_{ipso}–CO), 161.4 (*C*=CH), 188.7 (CO), 192.5 (CS).

*4.2.7. 2-((4-Hydroxy)-4-phenyl-3-propyl-2-thioxo-1,3-thiazolan-5-yliden)-1-phenyl-1-ethanone (**5g**).* Yellow powder, mp 198–200 °C, 0.05 g, yield: 13%. R_f (12% EtOAc/*n*-hexane): 0.35; IR (KBr) (ν_{max}, cm^{-1}): 3250 (OH), 1640 (C=O), 1595 (C=C), 1552 and 1447 (Ar), 1048 (C=S). Anal. Calcd for $C_{20}H_{19}NO_2S_2$ (369.49): C, 65.01; H, 5.18; N, 3.79%. Found: C, 65.04; H, 5.20; N, 3.82%. MS (EI, 70 eV): *m*/*z* (%)=369 (M^+, 14), 355 (10), 269 (19), 264 (16), 211 (11), 163 (37), 105 (100), 91 (10), 85 (18), 77 (79), 58 (24), 43 (65), 41 (16). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=0.79 (3H, t, $^3J_{HH}$=7.4 Hz, $NCH_2CH_2CH_3$), 1.37–1.41 (1H, m, $NCH_2CH_2CH_3$), 1.64–1.68 (1H, m, $NCH_2CH_2CH_3$), 3.28–3.33 (1H, m, $NCH_2CH_2CH_3$), 3.70–3.76 (1H, m, $NCH_2CH_2CH_3$), 4.19 (1H, br, OH), 7.04 (1H, s, C=C*H*), 7.35 (2H, t, $^3J_{HH}$=7.4 Hz, 2CH of Ar), 7.39–7.44 (4H, m, 4CH of Ar), 7.52 (2H, d, $^3J_{HH}$=8.1 Hz, 2CH of Ar), 7.78 (2H, d, $^3J_{HH}$=7.5 Hz, 2CH of Ar). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=10.98 ($NCH_2CH_2CH_3$), 20.4 ($NCH_2CH_2CH_3$), 47.5 ($NCH_2CH_2CH_3$), 101.4 (COH), 113.1 (C=*C*H), 125.4 (2CH of Ar), 128.4 (2CH of Ar), 128.6 (CH of Ar), 128.9 (2CH of Ar), 129.6 (CH of Ar), 133.3 (2CH of Ar), 133.7 (C_{ipso}–OH), 134.8 (CH of Ar), 138.3 (C_{ipso}–CO), 162.1 (*C*=CH), 189.2 (CO), 191.9 (CS).

*4.2.8. 2-(4-Hydroxy-3-isobutyl-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden)-1-phenyl-1-ethanone (**5h**).* Orange powder, mp 141–143 °C, 0.14 g, yield: 38%. R_f (12% EtOAc/*n*-hexane): 0.37; IR (KBr) (ν_{max}, cm^{-1}): 3285 (OH), 1623 (C=O), 1595 (C=C), 1540 and 1446 (Ar), 1051 (C=S).Anal. Calcd for $C_{21}H_{21}NO_2S_2$ (383.52): C, 65.77; H, 5.52; N, 3.65%. Found: C, 65.83; H, 5.55; N, 3.66%. MS (EI, 70 eV): *m*/*z* (%)=327 (4), 300 (12), 290 (16), 268 (35), 262 (9), 163 (41), 146 (17), 115 (20), 105 (100), 91 (38), 77 (95), 57 (28), 43 (37), 41 (39). ^{1}H NMR (500.1 MHz, $CDCl_3$): δ_H=0.81 (3H, d, $^3J_{HH}$=6.7 Hz, $NCH_2CH(CH_3)_2$), 0.88 (3H, d, $^3J_{HH}$=6.9 Hz, $NCH_2CH(CH_3)_2$), 2.09–2.16 (1H, m, $NCH_2CH(CH_3)_2$), 3.13 (1H, dd, $^2J_{HH}$=13.7 Hz, $^3J_{HH}$=8.0 Hz, $NCH_2CH_2CH_3$), 3.79 (1H, dd, $^2J_{HH}$=13.7 Hz, $^3J_{HH}$=6.8 Hz, $NCH_2CH_2CH_3$), 3.80–3.98 (1H, br, OH), 7.04 (1H, s, C=C*H*), 7.31 (2H, t, $^3J_{HH}$=7.4 Hz, 2CH of Ar), 7.37–7.41 (4H, m, 4CH of Ar), 7.52 (2H, d, $^3J_{HH}$=7.5 Hz, 2CH of Ar), 7.76 (2H, d, $^3J_{HH}$=7.2 Hz, 2CH of Ar). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=20.6 ($NCH_2CH(CH_3)_2$), 20.8 ($NCH_2CH(CH_3)_2$), 27.5 ($NCH_2CH(CH_3)_2$), 53.5 ($NCH_2CH(CH_3)_2$), 102.2 (COH), 113.3 (C=*C*H), 125.3 (2CH of Ar), 128.3 (2CH of Ar), 128.6 (2CH of Ar), 129.0 (2CH of Ar), 129.5 (CH of Ar), 133.2 (CH of

Ar), 136.7 (C_{ipso}–OH), 139.3 (C_{ipso}–CO), 162.0 (*C*=CH), 188.6 (CO), 193.7 (CS).

*4.2.9. 2-[4-Hydroxy-3-(4-methylbenzyl)-4-(4-methylphenyl)-2-thioxo-1,3-thiazolan-5-yliden]-1-(4-methylphenyl)-1-ethanone (**5i**).* Yellow powder, mp 23–205 °C, 0.12 g, yield: 27%. R_f (12% EtOAc/*n*-hexane): 0.26; IR (KBr) (ν_{max}, cm^{-1}): 3247 (OH), 1631 (C=O), 1562 (C=C), 1520 and 1452 (Ar), 1046 (C=S). Anal. calcd for $C_{27}H_{25}NO_2S_2$ (459.62): C, 70.56; H, 5.48; N, 3.05%. Found: C, 70.60; H, 5.42; N, 3.07%. MS (EI, 70 eV): *m*/*z* (%)=460 (M^++1,12), 443 (6), 297 (47), 279 (10), 264 (15), 177 (51), 119 (100), 105 (59), 91 (55), 77 (10), 65 (21). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=2.22 (3H, s, Me), 2.27 (3H, s, Me), 2.32 (3H, s, Me), 4.60 (1H, d, $^2J_{HH}$=14.8Hz, CH_2N), 4.79 (1H, br, OH), 5.15 (1H, d, $^2J_{HH}$=14.8 Hz, CH_2N), 6.95 (2H, d, $^3J_{HH}$=7.8 Hz, 2CH of Ar), 7.96 (1H, s, C=*CH*), 7.06 (2H, d, $^3J_{HH}$=7.7 Hz, 2CH of Ar), 7.10 (2H, d, $^3J_{HH}$=7.9 Hz, 2CH of Ar), 7.13 (2H, d, $^3J_{HH}$=7.6 Hz, 2CH of Ar), 7.33 (2H, d, $^3J_{HH}$=7.7 Hz, 2CH of Ar), 7.61 (2H, d, $^3J_{HH}$=7.7 Hz, 2CH of Ar). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=21.1 (CH_3), 21.1 (CH_3), 21.6 (CH_3), 48.6 (CH_2N), 102.2 (COH), 113.5 (C=*CH*), 125.4 (2CH of Ar), 128.5 (2CH of Ar), 128.7 (2CH of Ar), 128.8 (2CH of Ar), 129.3 (2CH of Ar), 129.4 (2CH of Ar), 133.5 (C_{ipso}–Me), 134.1 (C_{ipso}–Me), 136.0 (C_{ipso}–COH), 136.9 (C_{ipso}–CH_2N), 139.5 (C_{ipso}–Me), 144.3 (C_{ipso}–CO), 161.1 (*C*=CH), 188.2 (CO), 193.8 (CS).

*4.2.10. 2-[4-Hydroxy-3-(4-methylbenzyl)-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden]-1-phenyl-1-ethanone (**6a**).* Yellow powder, mp 98–100 °C, 0.26 g, yield: 60%. R_f (12% EtOAc/*n*-hexane): 0.34; IR (KBr) (ν_{max}, cm^{-1}): 3325 (OH), 1668 (C=O), 1595 (C=C), 1552 and 1448 (Ar), 1070 (C=S). Anal. Calcd for $C_{25}H_{21}NO_2S_2$ (431.56): C, 69.58; H, 4.90; N, 3.25%. Found: C, 69.61; H, 4.93; N, 3.26%. MS (EI, 70 eV): *m*/*z* (%)=357 (8), 356 (17), 355 (50), 250 (31), 235 (14), 146 (21), 105 (100), 91 (42), 77 (38), 51 (31). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=2.30 (3H, s, Me), 4.35 (2H, d, $^2J_{HH}$=6.0 Hz, CH_2N), 5.81 (1H, s, C=*CH*), 7.08 (2H, d, $^3J_{HH}$=7.9 Hz, 2CH of Ar), 7.13 (2H, d, $^3J_{HH}$=7.9 Hz, 2CH of Ar), 7.39 (2H, t, $^3J_{HH}$=7.2 Hz, 2CH of Ar), 7.45 (1H, t, $^3J_{HH}$=7.2 Hz, CH of Ar), 7.50 (2H, t, $^3J_{HH}$=7.7 Hz, 2CH of Ar), 7.65 (1H, t, $^3J_{HH}$=7.4 Hz, CH of Ar), 7.85 (2H, d, $^3J_{HH}$=7.1 Hz, 2CH of Ar), 8.02 (2H, d, $^3J_{HH}$=7.1 Hz, 2CH of Ar), 11.08 (1H, s, OH). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=21.0 (CH_3), 48.7 (CH_2N), 91.2 (COH), 127.2 (C=*CH*), 127.2 (2CH of Ar), 127.7 (2CH of Ar), 128.3 (2CH of Ar), 128.9 (2CH of Ar), 129.4 (2CH of Ar), 130.2 (2CH of Ar), 131.4 (CH of Ar), 134.2 (C_{ipso}–Me), 134.6 (CH of Ph), 134.7 (C_{ipso}–COH), 137.5 (C_{ipso}–CO), 139.5 (C_{ipso}–CH_2N), 1160.5 (*C*=CH), 190.1 (CO), 191.7 (CS).

*4.2.11. 2-[3-(4-Chlorobenzyl)4-hydroxy-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden]-1-phenyl-1-ethanone (**6b**).* Pale yellow powder, mp 70–72 °C, 0.24 g, yield: 54%. R_f (12% EtOAc/*n*-hexane): 0.31; IR (KBr) (ν_{max}, cm^{-1}): 3300 (OH), 1671 (C=O), 1596 (C=C), 1565 and 1436 (Ar), 1044 (C=S). Anal. Calcd for $C_{24}H_{18}ClNO_2S_2$ (451.98): C, 63.78; H, 4.01; N, 3.10%. Found: C, 63.79; H, 4.04; N, 3.11%. MS (EI, 70 eV): *m*/*z* (%)=453 (M^++2, 5), 451 (M^+, 16), 423 (10), 377(15), 368 (22), 313 (26), 299 (26), 264 (33), 236 (47), 125 (90), 105 (100), 77 (75), 67 (47), 57 (29), 43 (33). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=4.50 (2H, d, $^2J_{HH}$=6.5 Hz, CH_2N), 5.85 (1H, s, C=*CH*), 7.20 (2H, d, $^3J_{HH}$=7.3 Hz, 2CH of Ar), 7.31 (2H, d, $^3J_{HH}$=7.3 Hz, 2CH of Ar), 7.39 (2H, t, $^3J_{HH}$=7.2 Hz, 2CH of Ar), 7.43 (1H, t, $^3J_{HH}$=7.5 Hz, CH of Ar), 7.49 (2H, t, $^3J_{HH}$=7.9 Hz, 2CH of Ar), 7.65 (1H, t, $^3J_{HH}$=7.4 Hz, CH of Ar), 7.85 (2H, d, $^3J_{HH}$=7.2 Hz, 2CH of Ar), 8.03 (2H, d, $^3J_{HH}$=7.2 Hz, 2CH of Ar), 11.10 (1H, s, OH). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=46.7 (CH_2N), 91.8 (COH), 127.1 (C=*CH*), 127.3 (2CH of Ar), 127.9 (2CH of Ar), 128.4 (2CH of Ar), 128. 9 (2CH of Ar), 129.6 (2CH of Ar), 130.2 (2CH of Ar), 131.5 (CH of Ar), 133.5 (C_{ipso}–Cl), 134.7 (CH of Ph), 134.7 (C_{ipso}–COH), 135.0 (C_{ipso}–CO), 139.4 (C_{ipso}–CH_2N), 160.3 (*C*=CH), 190.3 (CO), 191.63 (CS).

*4.2.12. 2-[4-Hydroxy-3-(4-methoxybenzyl)-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden]-1-phenyl-1-ethanone (**6c**).* Pale yellow powder, mp 133–135 °C, 0.28 g, yield: 62%. R_f (12% EtOAc/*n*-hexane): 0.15; IR (KBr) (ν_{max}, cm^{-1}): 3460 (OH), 1669 (C=O), 1595 (C=C), 1551 and 1449 (Ar), 1031 (C=S). Anal. Calcd for $C_{25}H_{21}NO_3S_2$ (447.56): C, 67.09; H, 4.73; N, 3.13%. Found: C, 67.12; H, 4.74; N, 3.12%. MS (EI, 70 eV): *m*/*z* (%)=445 (M^+–2, 7), 385 (9), 371 (15), 280 (21), 266 (26), 147 (12), 121 (100), 105 (51), 91 (9), 77 (41), 51 (8). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=3.76 (3H, s, OMe), 4.32 (2H, d, $^2J_{HH}$=6.2 Hz, CH_2N), 5.80 (1H, s, C=*CH*), 6.80 (2H, d, $^3J_{HH}$=8.6 Hz, 2CH of Ar), 7.16 (2H, d, $^3J_{HH}$=8.6 Hz, 2CH of Ar), 7.38 (2H, t, $^3J_{HH}$=7.1 Hz, 2CH of Ar), 7.45 (1H, t, $^3J_{HH}$=7.2 Hz, CH of Ar), 7.50 (2H, t, $^3J_{HH}$=7.6 Hz, 2CH of Ar), 7.65 (1H, t, $^3J_{HH}$=7.4 Hz, CH of Ar), 7.84 (2H, d, $^3J_{HH}$=7.2 Hz, 2CH of Ar), 8.02 (2H, d, $^3J_{HH}$=7.2 Hz, 2CH of Ar), 11.04 (1H, s, OH). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=48.4 (OCH_3), 55.3 (CH_2N), 91.2 (COH), 114.2 (2CH of Ar), 125.4 (C=*CH*), 127.2 (2CH of Ar), 128.3 (2CH of Ar), 128. 9 (2CH of Ar), 129.1 (2CH of Ar), 129.4 (C_{ipso}–CH_2N), 130.2 (2CH of Ar), 131.4 (CH of Ar), 134.6 (CH of Ar), 134.7 (C_{ipso}–OH), 139.4 (C_{ipso}–CO), 159.3 (C_{ipso}–OMe), 160.5 (*C*=CH), 190.1 (CO), 191.7 (CS).

*4.2.13. 2-(3-Benzyl-4-hydroxy-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden)-1-phenyl-1-ethanone (**6d**).* Pale yellow powder, mp 180–182 °C, 0.22 g, yield: 54%. R_f (12% EtOAc/*n*-hexane): 0.32; IR (KBr) (ν_{max}, cm^{-1}): 3431 (OH), 1651 (C=O), 1577 (C=C), 1560 and 1447 (Ar), 1046 (C=S). Anal. Calcd for $C_{24}H_{19}NO_2S_2$ (417.54): C, 69.04; H, 4.59; N, 3.35%. Found: C, 69.06; H, 4.62; N, 3.34%. MS (EI, 70 eV): *m*/*z* (%)=315 (41), 296 (17), 250 (10), 155 (63), 140 (12), 91 (100), 65 (29), 51 (5). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=4.39 (2H, d, $^2J_{HH}$=6.3 Hz, CH_2N), 5.82 (1H, s, C=*CH*), 7.23–7.30 (5H, m, 5CH of Ar), 7.39 (2H, t, $^3J_{HH}$=7.2 Hz, 2CH of Ar), 7.46 (1H, t, $^3J_{HH}$=7.1 Hz, CH of Ar), 7.50 (2H, t, $^3J_{HH}$=7.5 Hz, 2CH of Ar), 7.65 (1H, t, $^3J_{HH}$=7.4 Hz, CH of Ar), 7.83 (2H, d, $^3J_{HH}$=8.2 Hz, 2CH of Ar), 8.02 (2H, d, $^3J_{HH}$=8.01 Hz, 2CH of Ar), 11.12 (1H, s, OH). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=48.8 (CH_2N), 91.3 (COH), 127.1 (C=*CH*), 127.6 (2CH of Ar), 127.7 (2CH of Ar), 128.3 (2CH of Ar), 128. 7 (2CH of Ar), 128.8 (2CH of Ar), 130.1 (2CH of Ar), 131.3 (CH of Ar), 134.5 (C_{ipso}–CH_2N), 134.6 (CH of Ar), 137.2 (C_{ipso}–OH), 139.3 (C_{ipso}–CO), 160.4 (*C*=CH), 190.1 (CO), 191.6 (CS).

*4.2.14. 2-[4-Hydroxy-4-phenyl-3-(1-phenylethyl)-2-thioxo-1,3-thiazolan-5-yliden]-1-phenyl-1-ethanone (**6e**).* Pale yellow powder, mp 124–126 °C, 0.2 g, yield: 46%. R_f (12% EtOAc/*n*-hexane): 0.33; IR (KBr) (ν_{max}, cm^{-1}): 3438 (OH), 1670 (C=O), 1570 (C=C), 1565 and 1440 (Ar), 1056 (C=S). Anal. Calcd for $C_{25}H_{21}NO_2S_2$ (431.56): C, 69.58; H, 4.90; N, 3.25%. Found: C, 69.61; H, 4.91; N, 3.28%. MS (EI, 70 eV): *m*/*z* (%)=236 (24), 130 (12), 105 (47), 102 (100), 77 (38), 51 (7). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=1.60 (1H, d, $^3J_{HH}$=6.6 Hz, $CHCH_3$), 4.61–4.67 (1H, m, *CH*CH_3), 5.76 (1H, s, C=*CH*), 7.14 (1H, t, $^3J_{HH}$=6.7 Hz, CH of Ar), 7.17–7.22 (4H, m, 4CH of Ar), 7.38–7041 (4H, m, 4CH of Ar), 7.46 (1H, t, $^3J_{HH}$=7.0 Hz, CH of Ar), 7.57 (1H, t, $^3J_{HH}$=7.4Hz, CH of Ar), 7.86 (4H, d, $^3J_{HH}$=7.1 Hz, 4CH of Ar), 11.26 (1H, s, OH). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=24.2 ($CHCH_3$), 54.3 (*CH*CH_3), 91.4 (COH), 126.2 (C=*CH*), 127.1 (2CH of Ar), 127.2 (2CH of Ar), 128.3 (2CH of Ar), 128. 5 (2CH of Ar), 128.6 (2CH of Ar), 130.0 (2CH of Ar), 131.3 (CH of Ar), 134.3 (CH of Ar), 134.5 (C_{ipso}–CH_2N), 139.3 (C_{ipso}–OH), 143.1 (C_{ipso}–CO), 159.9 (*C*=CH), 190.0 (CO), 191.6 (CS).

*4.2.15. 2-(4-Hydroxy-3-methyl-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden)-1-phenyl-1-ethanone (**6f**).* Orange oil, 0.09 g, yield: 27%. R_f (12% EtOAc/*n*-hexane): 0.25; IR (KBr) (ν_{max}, cm^{-1}): 3430 (OH), 1627 (C=O), 1593 (C=C), 1537 and 1443 (Ar), 1053 (C=S). Anal. Calcd for $C_{18}H_{15}NO_2S_2$ (341.44): C, 63.32; H, 4.43; N, 4.10%. Found: C, 63.36; H, 4.45; N, 4.11%. MS (EI, 70 eV): *m*/*z* (%)=341 (5), 266 (73), 248 (19), 236 (7), 160 (95), 147 (17), 118 (12), 105 (100), 77 (63), 69 (8), 51 (27). ^{1}H NMR (500.1 MHz, $CDCl_3$): δ_H=2.90 (3H, s, NMe), 5.74 (1H, s, C=*CH*), 7.37 (2H, t, $^3J_{HH}$=7.8 Hz, 2CH of Ar), 7.41 (1H, t, $^3J_{HH}$=7.3 Hz, CH of Ar), 7.54 (2H, t, $^3J_{HH}$=7.5 Hz, 2CH of Ar), 7.67 (1H, t,

$^3J_{HH}$=7.3 Hz, CH of Ar), 7.81 (2H, d, $^3J_{HH}$=7.6 Hz, 2CH of Ar), 8.04 (2H, d, $^3J_{HH}$=7.8 Hz, 2CH of Ar), 10.71 (1H, s, OH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C=31.5 (NCH_3), 90.6 (COH), 125.1 (C=*C*H), 127.2 (2CH of Ar), 128.3 (2CH of Ar), 129.1 (2CH of Ar), 130.1 (2CH of Ar), 131.3 (CH of Ar), 134.5 (C_{ipso}–OH), 134.9 (CH of Ar), 139.5 (C_{ipso}–CO), 161.8 (*C*=CH), 188.3 (CO), 190.2 (CS).

*4.2.16. 2-((4-Hydroxy)-4-phenyl-3-propyl-2-thioxo-1,3-thiazolan-5-yliden)-1-phenyl-1-ethanone (**6g**).* Yellow powder, mp 100–102 °C, 0.25 g, yield: 69%. R_f (12% EtOAc/*n*-hexane): 0.42; IR (KBr) (ν_{max}, cm^{-1}): 3195 (OH), 1677 (C=O), 1595 (C=C), 1553 and 1447 (Ar), 1056 (C=S). Anal. Calcd for $C_{20}H_{19}NO_2S_2$ (369.49): C, 65.01; H, 5.18; N, 3.79%. Found: C, 65.06; H, 5.22; N, 3.81%. MS (EI, 70 eV): *m*/*z* (%)= 369 (M^+, 19), 341 (7), 269 (33), 236 (11), 163 (76), 105 (100), 85 (13), 77 (64), 51 (13), 43 (8). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=0.93 (3H, t, $^3J_{HH}$=7.4 Hz, $NCH_2CH_2CH_3$), 1.61 (2H, t, $^3J_{HH}$=7.2 Hz, $NCH_2CH_2CH_3$), 3.13 (2H, q, $^3J_{HH}$=6.7 Hz, $NCH_2CH_2CH_3$), 5.73 (1H, s, C=C*H*), 7.37 (2H, t, $^3J_{HH}$=7.7 Hz, 2CH of Ar), 7.42 (1H, t, $^3J_{HH}$=7.2 Hz, CH of Ar), 7.53 (2H, t, $^3J_{HH}$=7.7 Hz, 2CH of Ar), 7.66 (1H, t, $^3J_{HH}$=7.4 Hz, CH of Ar), 7.83 (2H, d, $^3J_{HH}$=7.2 Hz, 2CH of Ar), 8.06 (2H, d, $^3J_{HH}$=7.4 Hz, 2CH of Ar), 10.89 (1H, s, OH). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=11.1 ($NCH_2CH_2CH_3$), 23.9 ($NCH_2CH_2CH_3$), 47.0 ($NCH_2CH_2CH_3$), 90.3 (COH), 125.4 (C=*C*H), 127.1 (2CH of Ar), 128.3 (2CH of Ar), 129.0 (2CH of Ar), 130.1 (2CH of Ar), 131.3 (CH of Ar), 134.6 (C_{ipso}–OH), 134.8 (CH of Ar), 139.5 (C_{ipso}–CO), 161.4 (*C*=CH), 190.0 (CO), 191.7 (CS).

*4.2.17. 2-(4-Hydroxy-3-isobutyl-4-phenyl-2-thioxo-1,3-thiazolan-5-yliden)-1-phenyl-1-ethanone (**6h**).* Yellow oil, 0.18 g, yield: 47%. R_f (12% EtOAc/*n*-hexane): 0.50; IR (KBr) (ν_{max}, cm^{-1}): 3440 (OH), 1676 (C=O), 1595 (C=C), 1553 and 1462 (Ar), 1051 (C=S). Anal. Calcd for $C_{21}H_{21}NO_2S_2$ (383.52): C, 65.77; H, 5.52; N, 3.65%. Found: C, 65.85; H, 5.54; N, 3.67%. MS (EI, 70 eV): *m*/*z* (%)=338 (5), 308 (25), 307 (54), 264 (47), 202 (34), 146 (100), 128 (11), 105 (39), 91 (15), 77 (29), 57 (18). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=0.89 (3H, d, $^3J_{HH}$=6.5 Hz, $NCH_2CH(CH_3)_2$), 0.92 (3H, d, $^3J_{HH}$=6.6 Hz, $NCH_2CH(CH_3)_2$), 1.81–1.85 (1H, m, $NCH_2CH(CH_3)_2$), 3.01 (2H, t, $^3J_{HH}$=6.5 Hz, $NCH_2CH(CH_3)_2$), 5.65 (1H, s, C=C*H*), 7.26 (2H, t, $^3J_{HH}$=7.6 Hz, 2CH of Ar), 7.37 (1H, t, $^3J_{HH}$=7.4 Hz, CH of Ar), 7.55 (2H, t, $^3J_{HH}$=7.5 Hz, 2CH of Ar), 7.68 (1H, t, $^3J_{HH}$=7.3 Hz, CH of Ar), 7.76 (2H, d, $^3J_{HH}$=8.1 Hz, 2CH of Ar), 8.06 (2H, d, $^3J_{HH}$=8.1 Hz, 2CH of Ar), 10.91 (1H, s, OH). ^{13}C NMR (125.7 MHz, $CDCl_3$): δ_C=19.9 ($NCH_2CH(CH_3)_2$), 29.4 ($NCH_2CH(CH_3)_2$), 53.0 ($NCH_2CH(CH_3)_2$), 90.3 (COH), 125.3 (C=*C*H), 127.2 (2CH of Ar), 128.3 (2CH of Ar), 129.1 (2CH of Ar), 130.1 (2CH of Ar), 131.3 (CH of Ar), 134.5 (C_{ipso}–OH), 134.9 (CH of Ar), 139.4 (C_{ipso}–CO), 162.2 (*C*=CH), 190.1 (CO), 191.6 (CS).

*4.2.18. 2-[4-Hydroxy-3-(4-methylbenzyl)-4-(4-methylphenyl)-2-thioxo-1,3-thiazolan-5-yliden]-1-(4-methylphenyl)-1-ethanone (**6i**).* Yellow oil, 0.25 g, yield: 54%. R_f (12% EtOAc/*n*-hexane): 0.30; IR (KBr) (ν_{max}, cm^{-1}): 3426 (OH), 1669 (C=O), 1572 (C=C), 1550 and 1451 (Ar), 1177 (C=S). Anal. Calcd for $C_{27}H_{25}NO_2S_2$ (459.62): C, 70.56; H, 5.48; N, 3.05%. Found: C, 70.58; H, 5.45; N, 3.09%. MS (EI, 70 eV): *m*/*z* (%)=457 (M^+–2, 7), 443 (18), 383 (32), 366 (7), 264 (28), 195 (4), 177 (9), 119 (100), 105 (95), 91 (26), 77 (5), 65 (10). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=2.30 (3H, s, Me), 2.37 (3H, s, Me), 2.45 (3H, s, Me), 4.32 (2H, d, $^2J_{HH}$=6.2 Hz, CH_2N), 5.78 (1H, s, C=C*H*), 7.08 (2H, d, $^3J_{HH}$=7.9 Hz, 2CH of Ar), 7.13 (2H, d, $^3J_{HH}$=8.0 Hz, 2CH of Ar), 7.19 (2H, d, $^3J_{HH}$=8.0 Hz, 2CH of Ar), 7.30 (2H, d, $^3J_{HH}$=8.0 Hz, 2CH of Ar), 7.75 (2H, d, $^3J_{HH}$=8.2 Hz, 2CH of Ar), 7.93 (2H, d, $^3J_{HH}$=8.2 Hz, 2CH of Ar), 11.02 (1H, br, OH). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=21.0 (CH_3), 21.4 (CH_3), 21.9 (CH_3), 48.8 (CH_2N), 90.9 (COH), 113.2 (C=*C*H), 127.2 (2CH of Ar), 127.6 (2CH of Ar), 129.0 (2CH of Ar), 129.4 (2CH of Ar), 129.6 (2CH of Ar), 130.3 (2CH of Ar), 132.3 (C_{ipso}–Me), 134.3 (C_{ipso}–COH), 136.8 (C_{ipso}–Me), 137.4 (C_{ipso}–CO), 141.8 (C_{ipso}–CH_2N), 145.9 (C_{ipso}–Me), 160.6 (*C*=CH), 189.9 (CO), 191.4 (CS).

*4.2.19. 1-(2-{[(Isopropylamino)carbotioyl]sulfanyl}-4-oxo-4-phenyl-2-butenoyl)benzene (**9a**).* Yellow powder, mp 168–170 °C, 0.22 g, yield: 61%. R_f (12% EtOAc/*n*-hexane): 0.17; IR (KBr) (ν_{max}, cm^{-1}): 3410 (NH), 1627 and 1604 (C=O), 1578 (C=C), 1532 and 1445 (Ar), 1069 (C=S). Anal. Calcd for $C_{20}H_{19}NO_2S_2$ (369.49): C, 65.01; H, 5.18; N, 3.79%. Found: C, 65.06; H, 5.22; N, 3.80%. MS (EI, 70 eV): *m*/*z* (%)= 361 (5), 300 (12), 268 (15), 230 (21), 149 (37), 113 (46), 105 (56), 86 (27), 77 (71), 58 (44), 43 (100). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=0.98 (3H, t, $^3J_{HH}$=7.2 Hz, NCH_2CH_2), 3.45 (1H, heptet, $^3J_{HH}$=6.8 Hz, NCH_2CH_3), 3.65 (1H, heptet, $^3J_{HH}$=6.8 Hz, NCH_2CH_3), 6.26 (1H, s, C=C*H*), 7.06 (2H, d, $^3J_{HH}$=7.9 Hz, 2CH of Ar), 7.13 (2H, t, $^3J_{HH}$=7.4 Hz, 2CH of Ar), 7.30 (1H, t, $^3J_{HH}$=7.3 Hz, CH of Ar), 7.36 (1H, t, $^3J_{HH}$=7.2 Hz, CH of Ar), 7.41 (2H, t, $^3J_{HH}$=7.5 Hz, 2CH of Ar), 7.70 (2H, d, $^3J_{HH}$=7.5 Hz, 2CH of Ar), 10.95 (1H, s, NH). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=15.2 (NCH_2CH_3), 40.1 (NCH_2CH_3), 124.6 (C=*C*H), 127.6 (2CH of Ar), 128.1 (2CH of Ar), 128.2 (2CH of Ar), 128.9 (2CH of Ar), 131.7 (CH of Ar), 133.2 (CH of Ar), 136.8 (C_{ipso}–CO), 138.8 (C_{ipso}–CO), 153.9 (*C*=CH), 177.5 (CO), 192.4 (CO), 194.6 (CS).

*4.2.20. 1-(2-{[(Allylamino)carbotioyl]sulfanyl}-4-oxo-4-phenyl-2-butenoyl)benzene (**9b**).* Yellow powder, mp 164–166 °C, 0.27 g, yield: 75%. R_f (12% EtOAc/*n*-hexane): 0.20; IR (KBr) (ν_{max}, cm^{-1}): 3320 (NH), 1633 and 1599 (C=O), 1577 (C=C), 1534 and 1445 (Ar), 1068 (C=S). Anal. Calcd for $C_{20}H_{17}NO_2S_2$ (367.48): C, 65.37; H, 4.66; N, 3.81%. Found: C, 65.39; H, 4.68; N, 3.83%. MS (EI, 70 eV): *m*/*z* (%)= 279 (15), 255 (12), 186 (48), 167 (57), 149 (81), 135 (61), 113 (22), 105 (43), 84 (35), 77 (51), 71 (30), 57 (78), 43 (100). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=4.02–4.05 (1H, m, $NCH_2CH{=}CH_2$), 4.19–4.22 (1H, m, $NCH_2CH{=}CH_2$), 5.06–5.11 (2H, m, $NCH_2CH{=}CH_2$), 5.50–5.55 (1H, m, $NCH_2CH{=}CH_2$), 6.28 (1H, s, C=C*H*), 7.00 (2H, d, $^3J_{HH}$=7.3 Hz, 2CH of Ar), 7.15 (2H, t, $^3J_{HH}$=7.5 Hz, 2CH of Ar), 7.29 (1H, t, $^3J_{HH}$=7.3 Hz, CH of Ar), 7.36 (1H, t, $^3J_{HH}$=7.2 Hz, CH of Ar), 7.41 (2H, t, $^3J_{HH}$=7.5 Hz, 2CH of Ar), 7.69 (2H, d, $^3J_{HH}$=7.2 Hz, 2CH of Ar), 10.92 (1H, s, NH). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=47.4 ($NCH_2CH{=}CH_2$), 118.1 ($NCH_2CH{=}CH_2$), 126.9 (C=*C*H), 127.5 (2CH of Ar), 127.6 (2CH of Ar), 128.1 (2CH of Ar), 129.0 (2CH of Ar), 129.9 ($NCH_2CH{=}CH_2$), 131.8 (CH of Ar), 133.2 (CH of Ar), 136.8 (C_{ipso}–CO), 138.9 (C_{ipso}–CO), 153.6 (*C*=CH), 177.2 (CO), 192.6 (CO), 194.7 (CS).

*4.2.21. 1-[4-Oxo-4-phenyl-2-({[(1-phenylethyl)amino]carbothioyl}sulfanyl)-2-butenoyl]benzene (**9c**).* Yellow powder, mp 156–158 °C, 0.19 g, yield: 44%. R_f (12% EtOAc/*n*-hexane): 0.29; IR (KBr) (ν_{max}, cm^{-1}): 3360 (NH), 1664 and 1612 (C=O), 1578 (C=C), 1530 and 1444 (Ar), 1066 (C=S). Anal. Calcd for $C_{25}H_{21}NO_2S_2$ (431.56): C, 69.58; H, 4.90; N, 3.25%. Found: C, 69.63; H, 4.94; N, 3.27%. MS (EI, 70 eV): *m*/*z* (%)=255 (9), 225 (10), 202 (7), 167 (16), 149 (19), 135 (37), 122 (28), 105 (82), 91 (39), 84 (31), 77 (100), 69 (27), 57 (38), 51 (58), 43 (95), 41 (87). ^{1}H NMR (500.13 MHz, $CDCl_3$): δ_H=1.74 (3H, d, $^3J_{HH}$=6.7 Hz, $CHCH_3$), 5.30–5.33 (1H, $CHCH_3$), 6.66 (1H, s, C=C*H*), 6.88–6.91 (2H, m, 2CH of Ar), 7.06–7.16 (5H, m, 2CH of Ar), 7.22–7.28 (2H, m, 2CH of Ar), 7.31–7.40 (4H, m, 4CH of Ar), 7.46 (2H, d, $^3J_{HH}$=7.4 Hz, 2CH of Ar), 11.33 (1H, d, $^3J_{HH}$=10.3 Hz, NH). ^{13}C NMR (125.75 MHz, $CDCl_3$): δ_C=21.7 ($CHCH_3$), 54.5 ($CHCH_3$), 125.7 (C=*C*H), 126.3 (CH of Ar), 127.5 (2CH of Ar), 127.6 (2CH of Ar), 128.0 (2CH of Ar), 128.4 (2CH of Ar), 131.7 (CH of Ar), 133.1 (CH of Ar), 136.8 (C_{ipso}–CO), 139.0 (C_{ipso}–CO), 141.5 (C_{ipso}–NCH), 153.6 (*C*=CH), 175.7 (CO), 192.4 (CO), 194.2 (CS).

Supplementary data

Supplementary data related to this article can be found online at doi:10.1016/j.tet.2010.12.055.

References and notes

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