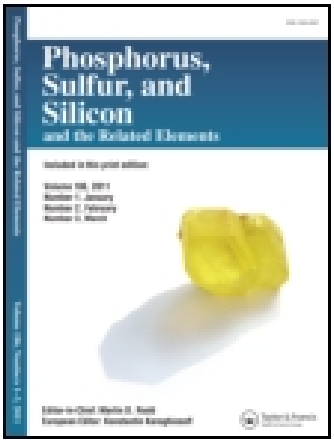

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REACTION OF ENAMINONES WITH THIACUMULENES

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REACTION OF ENAMINONES WITH THIACUMULENES

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Dedicated to Professor Dr Werner Schroth on the occasion of his 70 birthday

Enaminones **2**, easily prepared from the corresponding sodium salts of ß-ketoaldehydes **1** and hydrochlorides of primary amines, react with carbon disulfide/ sodium hydride to give dithiocarbamates **3** after alkylation. In a similar way thiocarbamoylation yields isothioureas **4**. The ^{13}C NMR parameters of **2**, **3** and **4** show significant low- and high-field shifts of the C-1 and C-2 signals, respectively.

Keywords: Enaminone; dithiocarboxylation; thiocarbamoylation; dithiocarbamate; isothiourea

INTRODUCTION

Continuing our previous work[1] we were interested in investigating reactions of enaminones, derived from primary amines, with thiacumulenes in a basic medium. The problem associated with C- and/or N-alkylation of enamines has been well discussed.[2] Nearly all reactions of enamines prepared from sec. amines lead selectively to C-alkylated compounds, but in some cases the probability of initial nitrogen-alkylation followed by N-to-C migration of the alkyl group is suggested.[3] Alkylations or acylations of enaminones derived from ß-ketoesters or dicarbonyl compounds are more complex because of the presence of three nucleophilic centers. Since undoubtedly the site of alkylation in an enaminone system depends on the steric requirement and the electronic character of both the alkyl halide and the substrate and on the reaction conditions including solvent, temperature and time, systematic investigations were done with representative enaminoketones.[4,5] The reaction of enamines with carbon disulfide was

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also studied[6a–c], always dithiocarboxylation was found to take place. Similarly, C-attack of enaminones or ß-sulfonyl enamines was reported in the reaction with isothiocyanates.[7] When 3-anilinoinden-1-ones were allowed to react with carbon disulfide in the presence of sodium hydroxide followed by treatment with dimethyl sulfate, methyl N-phenyl dithiocarbamate derivatives were obtained. However, the reaction of 3-anilino-2-cyclohexene-1-ones derived from dimedone gave under the same conditions the enamino dithiocarboxylate compounds.[8]

Walter and Fleck[9] systematically studied the reaction of phenyl isocyanate and various substituted phenyl isothiocyanates with enaminones derived from both primary and secondary amines. In all cases only the C-substituted product was obtained.

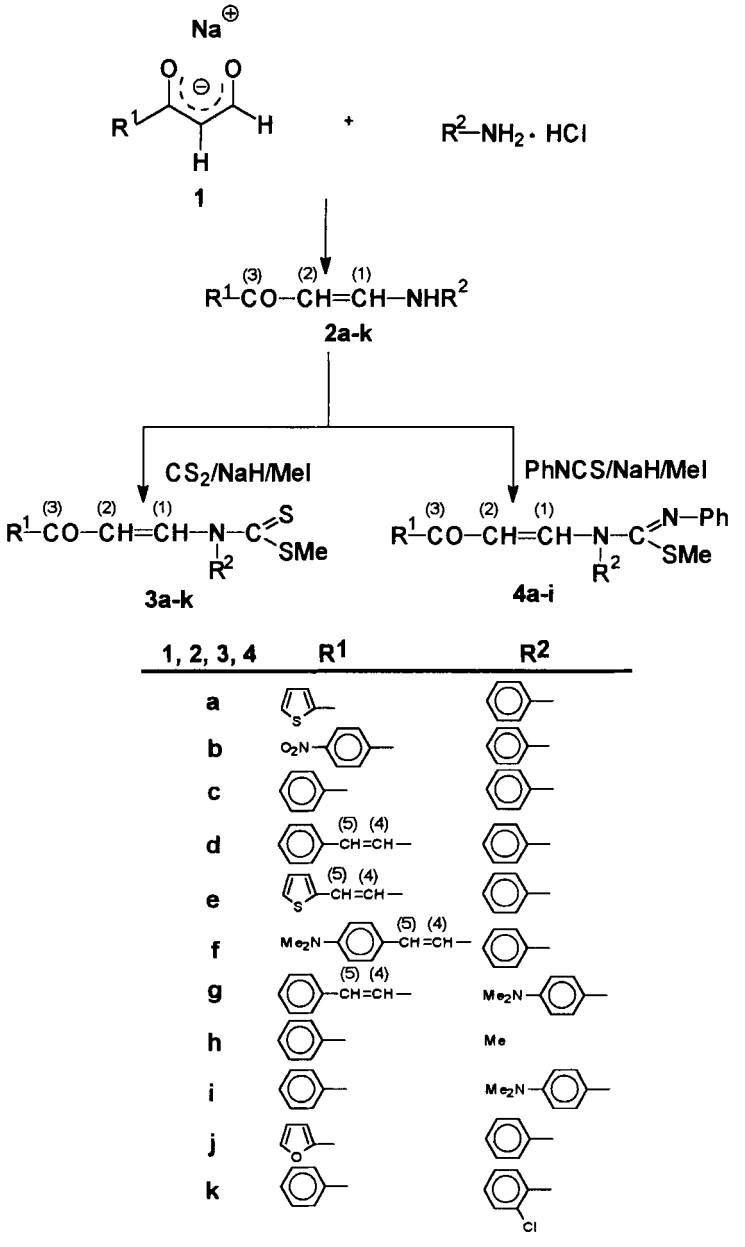
RESULTS AND DISCUSSION

We carried out the reaction of enaminones **2a-k**, easily prepared from the corresponding salts of ß-ketoaldehydes **1**[10a–b] and hydrochlorides of primary amines, with carbon disulfide in the presence of one equivalent of sodium hydride in dimethyl sulfoxide or dimethylformamide. The dithiocarboxylation was found to occur exclusively at the nitrogen atom of the amino group to give dithiocarbamates **3** after alkylation in good yields (Scheme 1). In case of **3f** the low yield, which could be somewhat improved by a prolonged reaction time, was possibly caused by the decreased nucleophilicity of the initially formed anion.

The enaminones **2a-i** also react with phenyl isothiocyanate in the presence of sodium hydride with DMF as solvent to give isothioureas **4a-i** after alkylation. Aryl groups with an electron withdrawing substituent both at the carbonyl group and at the nitrogen decrease the stability. Therefore, it is impossible to isolate a pure N-dithiocarbamoylated product **4k** even at −10 to −15°C.

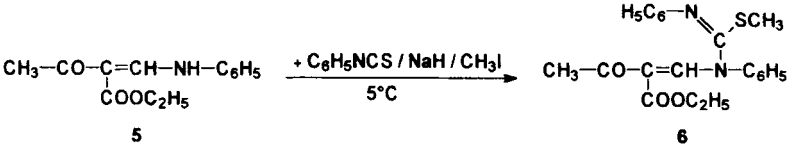
The enaminones **2a-k** exist in **Z**-form due to an intramolecular hydrogen bonding confirmed by large deshielding of NH-proton in ^{1}H-NMR spectra and also evident from the coupling constant of vinylogous protons (7–8 Hz).

The ^{1}H-NMR spectrum of **2b** in DMSO-d_6 shows two doublets at 6.17 ppm (J = 7.7 Hz) and 6.39 ppm (J =13.4 Hz) for a vinyl proton in α-position to the carbonyl group indicating the presence of both isomers, probably through rupture of hydrogen bond in a high polar solvent like DMSO.



SCHEME 1

The ^{1}H-NMR spectrum of ethyl 2-acetyl-3-anilino-acrylate **5**[10c] confirms a mixture of **E**- and **Z**-isomer in a ratio 1:8 with two seperate doublets at 8.62 (J = 14.0 Hz) and 8.84 ppm (J =13.2 Hz) for = CH-N =. A small amount of solid could be separated from this mixture which showed one signal at 8.84 ppm (J=13.2 Hz). From the theoretically calculated value for this proton according to Pascual et al.[11] the compound was assumed to be the **Z**-isomer. The corresponding isothiourea **6** obtained from enaminone **5** by thiocarbamoylation with phenyl isothiocyanate and following methylation was a mixture of both isomers (Scheme 2).



5 **6**

SCHEME 2

Selected ^{13}C-NMR parameters of **2a-g, j, k, 3a-f, j, k** and **4a-f, h** are listed in Tables I – III. Significant low- and high-field shifts of the C-1 and C-2 signals, respectively, show the charge polarization of the C,C double bond of these push-pull olefinic systems. As recently described , the ^{13}C chemical shift difference of the olefinic carbon atoms ($\Delta\delta C_1$-C_2) proved useful to indicate the degree of double bond character.[12–14] So this difference is dependent on the substituents at both the carbonyl and nitrogen atom of compounds **2, 3** and **4**.

TABLE I ^{13}C-chemical shifts of enaminones **2a-g, j, k**

	2a	*2b*	*2c*	*2d*	*2e*	*2f*	*2g*	*2j*	*2k*
δC_1	146.10	146.43	144.88	144.45	144.42	143.31	145.66	153.70	142.98
δC_2	93.68	93.60	93.70	98.03	98.30	98.30	96.95	93.43	95.26
$\Delta\delta C_1$-δC_2	52.42	52.83	52.19	46.42	46.12	45.01	48.71	60.27	47.72
δC_3	183.67	188.15	190.95	189.08	188.68	189.79	188.13	179.91	191.10
δC_4				127.56	126.83	122.78	129.38		
δC_5				139.50	132.23	140.44	138.60		

TABLE II ^{13}C-chemical shifts of dithiocarbamates **3a-f, j, k**

	3a	*3b*	*3c*	*3d*	*3e*	*3f*	*3j*	*3k*
δC_1	145.48	147.13	145.05	144.58	144.45	143.66	153.58	144.35
δC_2	109.22	108.64	109.71	113.80	113.79	114.50	109.11	109.25
$\Delta \delta C_1$-δC_2	36.26	38.49	36.34	30.78	30.74	29.16	44.69	35.10
δC_3	182.09	189.03	190.75	188.52	187.85	188.41	178.28	190.78
δC_4				124.60	123.71	119.94		
δC_5				139.12	134.89	149.37		

TABLE III ^{13}C-chemical shifts of isothioureas **4a-f, h**

	4a	*4b*	*4c*	*4d*	*4e*	*4f*	*4h*
δC_1	145.71	147.74	146.37	145.38	145.27	144.23	147.66
δC_2	103.64	103.07	103.90	108.09	108.03	108.49	100.81
$\Delta\delta C_1$-δC_2	42.07	44.67	42.47	37.29	37.24	39.74	46.85
δC_3	181.89	188.13	189.93	188.05	187.41	188.14	189.57
δC_4				123.96	123.95	121.30	
δC_5				141.32	133.86	142.12	

The enaminones **2** show a characteristic peak M^+-H. It appears very often as base peak in 3-aryl enaminones, but it was absent in **3** and **4**. In **3** M^+ -ArCO was the basepeak in nearly all cases and was also intensive in **4**. Both in **3** and **4** the molpeak M^+ was either very weak or did not appear at all.

EXPERIMENTAL

All melting points are uncorrected. P.E.(petroleum ether) used is of boiling range 40–60°C. IR spectra were recorded on a Zeiss Specord 71 IR using $CHCl_3$ as solvent. ^{1}H and ^{13}C-NMR spectra were taken on Bruker WP 200 and Bruker AC 80 spectrometers with TMS as internal standard (solvent

$CDCl_3$). Mass spectra were obtained on a M. v. Ardenne Mass Spectrograph (16 eV) and an EI-MS (AMD Intectra GmbH; 70 eV). Merck silica gel 60 (200–400 mesh) was used for column chromatography. Solvents were dried prior to use when necessary with appropriate drying agents. Microanalyses were performed by the Department of Chemistry, Martin Luther University Halle.

Preparation of Enaminones 2a-k (General Procedure)

A filtered aqueous solution (100 ml) of the sodium salt of ß-dicarbonyl compound **1** (0.1 mol) in water was added dropwise to a vigorously stirred solution of corresponding amine hydrochloride (0.1 mol) in water (100 ml) during 30 min. After further 30 min. stirring the resulting solid was filtered and washed. Final purification was done by either crystallisation or by column chromatography over neutral alumina with ether/ P.E. mixture.

(2-Anilino-vinyl) thien-2-yl ketone (2a)

Yield 72%, m.p. 108–109°C (ether/P.E.).- IR: $\nu = 3200$ cm^{-1}(NH), 1635 (C=O).- ^1H NMR: $\delta = 11.84$ (br. d, 1H, J = 10.36, NH), 7.64 – 7.01 (m, 9H, arom. and =CH-N), 5.87 (d, 1H, J = 7.83, =CHCO).- MS : m/z(%) = 229 (M^+), 228 (100) [M^+ - H].

$C_{13}H_{11}NOS$ (229.30) Calcd. C 68.10 H 4.84 N 6.11 S 13.98

Found C 68.12 H 4.84 N 6.08 S 14.10

(2-Anilino-vinyl) p-nitrophenyl ketone (2b)

Yield 47%, m.p. 177.5–178°C (CH_2Cl_2/ether).- IR: $\nu = 1635$ cm^{-1} (C=O).- ^1H NMR: δ(Z-form) = 12.24 (br. d, 1H, J = 11.73, NH), 8.27 (dd, 2H, J = 8.97 and 1.98, arom.), 8.04 (dd, 2H, J = 8.97 and 2.11, arom.), 7.59 (dd, 1 H, J = 12.59 and 7.68, = CH-N), 7.40 – 7.00 (m, 5H, arom.), 5.99 (d, 1H, J = 7.68). δ(Z- and E-form) (DMSO-d_6) = 8.33 – 8.01 (m, 5H, arom. and =CH-N), 7.39 – 6.99 (m, 5H, arom. H), 6.39 and 6.17 (2 × d, 1H, J = 13.42 and 7.74, E- = CHCO and Z-=CHCO).- MS: m/z(%) = 268 (68) [M^+].

$C_{15}H_{12}N_2O_3$ (268.28) Calcd. C 67.16 H 4.51 N 10.44

Found C 66.88 H 4.56 N 10.46

(2-Anilino-vinyl) phenyl ketone (2c)

Yield 82%, m.p. 138–139°C (ether/P.E.).- IR: $\nu = 3160\ cm^{-1}$(NH), 1630 (C=O).- ^1H NMR: $\delta = 12.13$ (d, 1H, J = 12.28, NH), 7.93 (dd, 2H, J = 7.95 and 1.86, arom. H), 7.56 – 7.02 (m, 9H, arom. H and =CH-N), 6.02 (d, 1H, J = 7.92, = CHCO).- MS: m/z(%) = 223 (56) [M^+], 222 (100) (M^+ -H).

1-Anilino-5-phenyl-penta-1,4-dien-3–one (2d)

Yield 42%, m.p. 156–157°C (ether/P.E.).- IR: $\nu = 1625\ cm^{-1}$(C=O).- ^1H NMR: $\delta = 12.16$ (d, J = 11.83, NH), 7.7 – 6.95 (m, 12H, arom. and vinylic H), 6.76 (d, 1H, J = 15.93, COCH=CPh), 5.51 (d, 1H, J = 7.65, COCH=C-N).- MS: m/z(%) = 249 (12.3) [M^+], 172 (100) [M^+ – Ph].

$C_{17}H_{15}NO$ (249.32) Calcd. C 81.90 H 6.06 N 5.62
Found C 81.82 H 5.99 N 5.74

1-Anilino-5-(thien-2-yl)-penta-1,4-dien-3-one (2e)

Yield 22%, m.p. 157–158°C (ether).- IR: $\nu = 1635\ cm^{-1}$ (C=O).- ^1H NMR: $\delta = 12.12$ (br. d, 1H, J = 10.46, NH), 7.68 (d, 1H, J = 15.57, ArCH =), 7.4 (q, 1H, J = 12.26 and 7.7, =CH-N), 7.33 – 7.22 (m, 4H, arom.), 7.08 – 7.0 (m, 4H, arom. H), 6.56 (d, 1H, J = 15.57, Ar-C=CH), 5.45 (d, 1 H, J = 7.7, CH = C-N).- MS: m/z(%) = 255 (43.6) [M^+] , 172 (100) [M^+ – Ph].

$C_{15}H_{13}NOS$ (255.34) Calcd. C 70.56 H 5.13 N 5.49 S 12.56
Found C 70.42 H 5.33 N 5.61 S 12.77

1-Anilino-5-(p-N,N-dimethylanilino)-penta-1,4-dien-3-one (2f)

Yield 53%, m.p. 215–217°C (CH_2Cl_2).- IR: $\nu = 1640\ cm^{-1}$ (C=O).- ^1H NMR: δ (Z-form) = 12.08 (br. d, 1H, J = 11.61, NH), 7.53 (d, 1H, J = 15.74, ArCH =), 7.45 (d, 2H, J = 8.88, arom.), 7.40 – 7.25 (m, 2H, arom.), 7.35 (q, 1H, J = 12.74 and 7.73, = CH-N), 7.06 – 6.98 (m, 1H, arom.), 7.04 (d, 2H, J = 7.96, arom.), 6.66 (d, 2H, J = 8.88, arom.), 6,58 (d, 1H, J = 15.74, ArC=CH), 5.47 (d, 1H, J = 7.7, CH = C-N), 3.00 (s, 6H, NMe_2). δ (Z- and E-form) = 12.09 (d, 1H, J = 11.89, NH), 9.4 (d, J = 14.05, E- = CH-N), 5.38 (d, J = 14.08, E- CH = C-N) [other protons of E-isomer show signal along with that of Z-isomer].

$C_{19}H_{20}N_2O$ (292.39) Calcd. C 78.05 H 6.90 N 9.58
Found C 78.20 H 6.91 N 9.31

1 -(N,N-Dimethyl-p-phenylenediamino)-5-phenyl-penta-1,4-dien-3-one (2g)

Yield 42%, m.p. 188–190°C (ethanol).- IR (KBr): ν = 1638 cm^{-1} (C=O).- ^1H NMR: δ = 12.32 (br. m, 1H, NH), 7.58 – 7.25 (m, 6H, arom. and = CH-Ph), 7.34 (d, 1H, J = 7.30, =CH-N), 7.0 (d, 2H, J = 9.02, arom.), 6.75 (d, 1H, J = 15.84, PhC=CH-CO), 6.70 (d, 2H, J = 9.02, arom.), 5.41 (d, 1H, J = 7.3, CH = C-N), 2.92 (s, 6H, NMe_2).

$C_{19}H_{20}N_2O$ (292.39) Calcd. C 78.05 H 6.90 N 9.58

Found C 78.96 H 6.71 N 5.74

(2-Methylamino-vinyl) phenyl ketone (2h)

Yield 80%, m.p. 137–138°C (ethanol).- IR: ν = 3255 cm^{-1} (NH), 1624 (C=O).- ^1H NMR: δ = 10.20 (br. s, 1H, NH), 7.9 – 7.79 (m, 2H, arom.), 7.46 –7.32 (m, 3H, arom.), 6.89 (dd, 1H, J = 12.78 and 7.33, =CH-N), 5.67 (d, 1H, J = 7.33, =CHCO).

$C_{10}H_{11}NO$ (161.21) Calcd. C 74.51 H 6.88 N 8.69

Found C 74.36 H 6.80 N 8.81

[2-(N,N -Dimethyl-p-phenylenediamino)-vinyl] phenyl ketone (2i)

Yield 99%, m.p. 175.5–177°C (ethanol).- IR (KBr): ν = 1636 cm^{-1} (C=O).- ^1H NMR: δ = 12.23 (br. d, 1H, J = 12.56, NH), 7.91 (m, 2H, arom.), 7.48 – 7.36 (m, 4H, arom. and =CHN), 6.90 (d, 2H, J = 8.97, arom.), 6.72 (d, 2H, J = 8.97, arom.), 5.93 (d, 1 H, J = 7.61, =CHCO), 2.92 (s, 6H, NMe_2).

$C_{17}H_{18}N_2O$ (266.35) Calcd. C 76.66 H 6.81 N 10.52

Found C 76.38 H 6.57 N 10.42

(2-Anilino-vinyl) fur-2-yl ketone (2j)

Yield 71%, m.p. 82–83°C (ether/P.E.).- IR: ν = 3120 cm^{-1}(NH), 1635 (C=O).- ^1H NMR: δ = 11.9 (d, 1H, J = 11.25, NH), 7.52–6.92 (m, 8H, arom. and =CH-N), 6.48 (q, 1H, furan ring), 5.9 (d, 1H, J = 7.83, = CHCO).- MS: m/z(%) = 213 (100) [M^+].

$C_{13}H_{11}O_2N$ (213.24) Calcd. C 73.23 H 5.20 N 6.57

Found C 73.17 H 5.20 N 6.44

(2-o-Chloroanilino-vinyl) phenyl ketone (2k)

Yield 53%, m.p. 88–90°C (ether/P.E.).- IR : $\nu = 1638$ cm^{-1}(C=O).- ^1H NMR: $\delta = 12.40$ (br. d, 1H, J = 11.80, NH), 7.95 (dd, 2H, J = 7.81 and 1.68, arom.), 7.54 – 6.92 (m, 8H, arom. and =CH-N), 6.11 (d, 1H, J = 7.98, = CHCO).- MS: m/z(%) = 257/259 (1.6 : 1.96) [M^+], 256 (100) [$M^+ - H$].

$C_{15}H_{12}ClNO$ (257.72) Calcd. C 69.91 H 4.69 N 5.43 Cl 13.76

Found C 70.15 H 4.88 N 5.65 Cl 13.65

Reaction of Enaminones 2 and 5 with Thiacumulenes (General Procedure)

NaH (0.31 g, 0.013 mol) was added portionwise to a solution of enaminone **2** (0.01 mol) and thiacumulene (0.01 mol) in 15–20 ml dried DMSO (reaction with CS_2) or DMF (reaction with phenyl isothiocyanate) under N_2 atmosphere with simultaneous stirring and cooling at 15°C during 15 min.

The stirring was continued for 4h at that temperature. Finally alkylating agent (0.013 mol) was added maintaining the temperature below 10°C and stirring was continued for another 2–3h. The reaction mixture was then poured into cold water. A solid was filtered while oily products were extracted with ether or ether/CH_2Cl_2, washed with water and dried over sodium sulfate. Purification was done either by crystallisation or by column chromatography.

Methyl N-[3-oxo-3-(thien-2-yl)-propen-1-yl]-N-phenyl dithiocarbamate (3a)

Yield 81%, m.p. 184–184.5°C (CH_2Cl_2/ether).- IR: $\nu = 1650$ cm^{-1} (C = O).- ^1H NMR: $\delta = 9.55$ (d, 1H, J = 13.63, =CH-N), 7.6 – 7.56 (m, 3H, arom.), 7.54 (dd, 1H, J = 4.96 and 1.12, arom.), 7.38 (dd, 1H, J = 3.82 and 1.12) , 7.30 - 7.24 (m, 2H, arom.), 7.02 (q, 1 H, J = 4.96 and 3.82, arom.), 5.73 (d, 1 H, J = 13.63, = CHCO), 2.57 (s, 3H, SMe).- MS: m/z(%) = 208 (100) [M^+ - C_4H_3SCO].

$C_{15}H_{13}NOS_3$ (319.47) Calcd. C 56.40 H 4.10 N 4.38 S 30.11

Found C 56.17 H 4.12 N 4.26 S 30.18

Methyl N-(p-nitrophenyl-3-oxo-propen-1-yl)-N-phenyl dithiocarbamate (3b)

Yield 67%, m.p. 174–175°C (CH_2Cl_2/ether).- IR: ν = 1660 cm^{-1} (C=O).- ^1H NMR: δ = 9.56 (d, 1H, J = 13.72, = CH-N), 8.28 - 8.14 (m, 2H, arom.), 7.90 - 7.74 (m, 2H, arom.), 7.65 – 7.52 (m, 5H, arom.), 5.77 (d, 1H, J = 13.72, = CHCO), 2.59 (s, 3H, SMe).

$C_{17}H_{14}N_2O_3S_2$(358.44) Calcd. C 56.97 H 3.94 N 7.82 S 17.89
Found C 56.66 H 3.90 N 7.58 S 17.89

Methyl N-(3-oxo-3-phenyl-propen-1-yl)-N-phenyl dithiocarbamate (3c)

Yield 70%, m.p. 196–198°C (CH_2Cl_2/ether).- IR: ν = 1659 cm^{-1} (C=O).- ^1H NMR: δ = 9.52 (d, 1H, J = 13.60, = CH-N); 7.69 - 7.27 (m, 10H, arom.); 5.83 (d, 1H, J = 13.60, = CHCO), 2.58 (s, 3H, SMe). MS: m/z(%) = 313 (100) [M^+].

$C_{17}H_{15}NOS_2$ (313.44) Calcd. C 65.14 H 4.82 N4.47 S 20.46
Found C 64.80 H 4.74 N 4.42 S 20.56

Methyl N-(3-oxo-5-phenyl-penta-1,4-dienyl)-N-phenyl dithiocarbamate (3d)

Yield 88%, m.p. 160–162°C (CH_2Cl_2/ether).- IR: ν = 1652 cm^{-1} (C=O).- ^1H NMR: δ = 9.55 (d, 1H, J = 14.07, =CH-N), 7.64 - 7.18 (m, 10H, arom.), 7.56 (d, 1H, J = 15.78, PhCH=), 6.87 (d, 1H, J = 15.78, PhC=CH), 5.40 (d, 1H, J = 14.07, CH = C-N), 2.58 (s, 3H, SMe).- MS: m/z(%) = 208 (100) [M^+ – PhCH = CHCO].

$C_{19}H_{17}NOS_2$ (339.48) Calcd. C 67.22 H 5.05 N 4.13 S 18.89
Found C 66.95 H 4.83 N 4.13 S 18.71

Methyl N-[3-oxo-5-(thien-2-yl)-penta-1,4-dienyl]-N-phenyl dithiocarbamate (3e)

Yield 77%, m.p. 181–182°C (CH_2Cl_2/ether).- IR: ν = 1664 cm^{-1} (C = O).- ^1H NMR: δ = 9.50 (d, 1H, J = 14.0, = CH-N), 7.68 (d, 1H, J = 15.42, ArCH =), 7.57 – 7.54 (m, 3H, arom.), 7.34 (d, 1 H, J = 5.02, arom.), 7.26 – 7.21 (m, 3H, arom.), 7.02 (dd, J = 5.02 and 3.65, arom.), 6.65 (d, 1H, J = 15.42, ArC = CH), 5.33 (d, 1H, J = 14.20, N-C = CH), 2.57 (s, 3H, SMe).- MS: m/z(%) = 208 (100) [$M^+ - C_4H_3SCH$ = CHCO].

$C_{17}H_{15}NOS_3$ (345.51) Calcd. C 59.10 H 4.38 N 4.05 S 27.84
Found C 58.80 H 4.49 N 4.12 S 28.02

Methyl N-(5-(p-N',N'-dimethylanilino)-3-oxo-penta-1,4-dienyl]-N-phenyl dithiocarbamate (3f)

Yield 35% (4h reaction time) and 50% (24h reaction time), m.p. 203–204°C (CH_2Cl_2/ether).- IR: $\nu = 1640$ cm^{-1}(C = O),.- ^1H NMR: $\delta = 9.48$ (d, 1H, J = 14.05, =CH-N), 7.57 - 7.53 (m, 3H, arom.), 7.44 (d, 1H, J = 15.9, ArCH =), 7.42 (d, 2H, J = 9.07, arom.), 7.27 – 7.22 (m, 2H, arom.), 6.70 (d, 1 H, J = 15.9, ArC=CH), 6.63 (d, 2H, J = 9.07, arom.), 5.38 (d, 1H, J = 14.05, CH = C-N), 2.99 (s, 6H, NMe_2), 2.57 (s, 3H, SMe).

$C_{21}H_{22}N_2OS_2$ (382.55) Calcd. C 65.93 H 5.80 N 7.32 S 16.76
Found C 65.57 H 5.61 N 6.99 S 17.00

Methyl N-(p-N ,N -dimethylanilino)-N-(3-oxo-5-phenyl-penta-1,4-dienyl)dithiocarbamate (3g)

Yield 98%, m.p. 259–261°C ($CHCl_3$/ ether).- IR (KBr): $\nu = 1658$ cm^{-1} (C=O).- ^1H NMR: $\delta = 9.55$ (d, 1H, J = 14.0, =CH-N), 7.56 (d, 1H, J = 15.89, PhCH =), 7.54 – 7.33 (m, 5H, arom.), 7.04 (d, 2H, J = 9.09, arom.), 6.93 (d, 1H, J = 15.89, Ph-C=CH), 6.75 (d, 2H, J = 9.09, arom.), 5.49 (d, 1H, J = 14.0, N-C = CH), 3.04 (s, 6H, NMe_2), 2.55 (s, 3H, SMe).

$C_{21}H_{22}N_2OS_2$ (382.55) Calcd. C 65.93 H 5.80 N 7.32
Found C 66.25 H 5.92 N 7.30

Methyl N-methyl-N-(3-oxo-3-phenyl-propen-1-yl) dithiocarbamate (3h)

Yield 64%, m.p. 127–128°C (ethanol).- IR (KBr): $\nu = 1652$ cm^{-1}(C = O).- ^1H NMR: $\delta = 9.0$ (d, 1H, J = 13.36, = CH-N), 7.92 (m, 2H, arom.), 7.59 – 7.41 (m, 3H, arom.), 6.55 (d, 1H, J = 13.36, = CHCO), 3.75 (s, 3H, NMe), 2.70 (s, 3H, SMe).

$C_{12}H_{13}NOS_2$ (251.37) Calcd. C 57.34 H 5.21 N 5.57 S 25.51
Found C 57.22 H 5.33 N 5.39 S 25.59

Methyl N-(p-N,N-dimethylanilino)-N-(3-oxo-3-phenyl-propen-1-yl) dithiocarbamate (3i)

Yield 95%, m.p. 246–248.5°C (ethanol).- IR (KBr): $\nu = 1647$ cm^{-1} (C = O).- ^1H NMR: $\delta = 9.52$ (d, 1H, J = 13.62, = CH-N), 7.73 (dd, 2H, J = 1.44 and 8.13, arom.), 7.48 – 7.33 (m, 3H, arom.), 7.07 (dd, 2H, J = 6.90 and 2.17, arom.), 6.77 (dd, 2H, J = 6.90 and 2.17, arom.), 3.05 (s, 6H, NMe_2), 2.54 (s, 3H, SMe).

$C_{19}H_{20}N_2OS_2$ (356.51) Calcd. C 64.01 H 5.65 N 7.86 S 17.99
Found C 63.05 H 5.83 N 7.81 S 17.49

Methyl N-[3-(fur-2-yl)-3-oxo-propen-1-yl]-N-phenyl dithiocarbamate (3j)

Yield 80%, m.p. 197.5–198°C (CH_2Cl_2/ ether).- IR: $\nu = 1655$ cm^{-1} (C = O).- ^1H NMR: $\delta = 9.59$ (d, 1H, J = 13.82, = CH-N),7.59 - 7.55 (m, 3H, arom.), 7.46 (dd, 1H, J = 1.71 and 0.7, arom.), 7.46 – 7.24 (m, 2H, arom.), 7.03 (dd, 1H, J = 3.56 and 0.7, arom.), 6.45 (q, 1H, J = 3.56 and 1.71, arom.), 5.73 (d, 1H, J = 13.82, = CHCO), 2.57 (s, 3H, SMe).- MS: m/z(%) = 208 (100) [$M^+ - C_4H_3OCO$].

$C_{15}H_{13}NO_2S_2$ (303.41) Calcd. C 59.38 H 4.32 N 4.62 S 21.14
Found C 60.05 H 4.60 N 5.27 S 21.16

Methyl N-o-chlorophenyl-N-(3-oxo-3-phenyl-propen-1-yl) dithiocarbamate(3k)

Yield 92%, m.p. 165–167°C (CH_2Cl_2/ether).- IR : $\nu = 1655$ cm^{-1} (C = O).- ^1H NMR: $\delta = 9.41$ (d, 1H, J = 13.8, =CH-N), 7.73 – 7.36 (m, 9H, arom.), 5.76 (d, 1H, J = 13.8, = CHCO), 2.60 (s, 3H, SMe).- MS: m/z(%) = 242/244 (100) [M^+ - PhCO].

$C_{17}H_{14}ClNOS_2$ (347.89) Calcd. C 58.69 H 4.06 N 4.03 Cl 10.19 S 18.43
Found C 58.87 H 4.17 N 4.10 Cl 10.13 S 18.45

S-Methyl-N-[3-oxo-3-(thien-2-yl)-propen-1 -yl]-N,N'-diphenyl isothiourea (4a)

Yield 92% , m.p. 102–103°C (ether).- IR (KBr): $\nu = 1644$ cm^{-1} (C = O), 1634 (C = N) .- ^1H NMR: $\delta = 8.49$ (br. d, 1H, J = 13.16, =CH-N), 7.52 - 6.98 (m, 11H, arom.), 6.9 (d, 2H, J = 7.85, arom.), 5.97 (d, 1H, J = 13.16, COCH=), 2.10 (s, 3H, SMe).- MS: m/z = 378 (M^+).

$C_{21}H_{18}N_2OS_2$ (378.52) Calcd. C 66.64 H 4.79 N 7.40 S 16.94
Found C 66.10 H 4.71 N 6.95 S 17.04

S-Methyl-N-(3-p-nitrophenyl-3-oxo-propen-1-yl)-N,N'-diphenyl isothiourea (4b)

Yield 86%, m.p. 78–80°C (ether/P.E.).- IR: $\nu = 1653$ cm^{-1}(C = O), 1615 (C = N).- ^1H NMR: $\delta = 8.5$ (d, 1H, J = 13.31, =CH-N), 8.22 (d, 2H, J = 8.82, arom.), 7.84 (d, 2H, J = 8.82, arom.), 7.5 – 6.9 (m, 8H, arom.),

6.91 (d, 2H, J = 8.47, arom.), 5.99 (d, 1 H, J = 13.31, COCH =), 2.15 (s, 3H, SMe). δ (DMSO) = 8.4 (d, 1H, J = 13.70, =CH-N), 8.26 (d, 2H, J = 8.86, arom.), 8.92 (d, 2H, J = 8.86, arom.), 7.57 – 7.01 (m, 8H, arom.), 6.94 (d, 2H, J = 7.31, arom.), 6.02 (d, 1H, J = 13.71, COCH =), 2.11 (s, 3H, SMe).- MS: m/z = 417 (M^+).

$C_{23}H_{19}N_3O_3S$ (417.49) Calcd. C 66.17 H 4.59 N 10.06 S 7.68
Found C 65.82 H 4.90 N 10.02 S 7.48

S-Methyl-N-(3-oxo-3-phenyl-propen-1-yl)-N,N′-diphenyl isothiourea (4c)

Yield 90%, m.p. 116–116.5°C (ether/P.E.).- IR: ν = 1648 cm^{-1}(C = O), 1613 (C = N).- ^1H NMR: δ = 8.5 (d, 1H, J = 13.39, =CH-N), 7.83 - 7.71 (m, 2H, arom.), 7.5 - 6.71 (m, 13H, arom.), 6.11 (d, 1H, J = 13.39, COCH=), 2.14 (s, 3H, SMe). δ [DMSO/CF_3CO_2H(1 drop)] = 8.39 (d, 1H, J = 13.48, =CH-N), 7.7 –7.66 (m, 2H, arom.), 7.57 – 6.92 (m, 13H, arom.), 6.0 (d, 1H, J = 13.39, COCH =), 2.09 (s, 3H, SMe).- MS: m/z(%) = 372 (10) [M^+].

$C_{23}H_{20}N_2OS$ (372.49) Calcd. C 74.16 H 5.41 N 7.52 S 8.61
Found C 73.90 H 5.52 N 7.45 S 8.89

S-Methyl-N-(3-oxo-5-phenyl-penta-1,4-dienyl)-N,N′-diphenyl isothiourea (4d)

Yield 90%, m.p. 132–133°C (ether/P.E.).- IR: ν = 1640 cm^{-1} (C = O), 1615 (C = N).- ^1H NMR: δ = 8.66 (d, 1H, J = 13.63, =CH-N), 7.52 (d, 2H, J = 15.77, PhCH=), 7.47 – 6.94 (m, 13H, arom.), 6.92 (d, 2H, J = 7.3, arom.), 6.75 (d, 1H, J = 15.77, Ph-C=CH), 5.57 (d, 1H, J = 13.63, N-C =CH), 2.09 (s, 3H, SMe).- MS: m/z = 351 (M^+ – SMe) .

$C_{25}H_{22}N_2OS$ (398.53) Calcd. C 75.35 H 5.56 N 7.03 S 8.05
Found C 75.65 H 5.51 N 7.08 S 8.21

S-Methyl-N-(3-oxo-5-(thien-2-yl)-penta-1,4-dienyl]-N,N′-diphenyl isothiourea (4e)

Yield 80%, m.p. 115–116.5°C (ether/P.E.).- IR: ν = 1657 cm^{-1}(C = O), 1638 (C = N).- ^1H NMR: δ = 8.41 (d, 1H, J = 13.0, CH = N), 7.65 (d, 1H, J = 15.45, PhCH =), 7.47 - 6.98 (m, 11H, arom.), 6.91 (d, 2H, J = 7.35, arom.), 6.53 (d, 1H, J = 15.45, PhC=CH), 5.51 (d, 1H, J = 13.0, N-C=CH), 2.09 (s, 3H, SMe).

$C_{23}H_{21}N_2OS_2$ (405.57) Calcd. C 68.12 H 5.22 N 6.91 S 15.81

Found C 67.93 H 4.94 N 6.88 S 15.99

S-Methyl-N-[5-(p-N ,N -dimethylanilino)-3-oxo-penta-1,4-dienyl]-N,N′-diphenyl isothiourea (4f)

Yield 71%, m.p. 150–151°C (CH_2Cl_2/ether).- IR: ν = 1657 cm^{-1}(C = O), 1640 (C = N).- ^1H NMR : δ = 8.48 (d, 1H, J = 15.85), 8.38, (d, 1H, J = 13.74, = CH-N), 7.39 (d, 2H, J = 8.99, arom.), 7.45 – 6.97 (m, 8H, arom.), 6.90 (d, 2H, J = 7.35, arom.), 6.62 (d, 2H, J = 8.99, arom.), 6.55 (d, 1H, J = 15.85, Ph-C=CH), 5.57 (d, 1H, J = 13.74, N-C=CH), 2.98 (s, 6H, NMe_2), 2.14 (s, 3H, SMe).- MS: m/z = 291 [M^+ -PhN =C-SMe].

$C_{27}H_{27}N_3OS$ (441.60) Calcd. C 73.44 H 6.16 N 9.52 S 7.26

Found C 73.03 H 6.30 N 9.37 S 7.43

N -(p-N,N -Dimethylanilino)-S-methyl-N-(3-oxo-5-phenyl-penta-1,4-dienyl)-N′-phenyl isothiourea (4g)

Yield 62%, m.p. 134–136°C (ethanol).- IR (KBr): ν = 1656 cm^{-1}(C = O), 1633 (C = N).- ^1H NMR: δ = 8.53 (d, 1H, J = 13.43, = CH-N), 7.50 (d, 1H, J = 15.82, PhCH=), 7.50 – 7.25 (m, 7H, arom.), 7.10 (d, 2H, J = 9.05, arom.), 7.05 – 6.94 (m, 3H, arom.), 6.73 (d, 1H, J = 15.82, Ph-C = CH), 6.72 (d, 2H, J = 9.05), 5.47 (d, 1H, J = 13.4, N-C=CH), 3.01 (s, 6H, NMe_2), 1.99 (s, 3H, SMe).

$C_{27}H_{27}N_3OS$ (441.60) Calcd. C 73.44 H 6.16 N 9.52

Found C 73.42 H 6.17 N 9.25

N-Methyl-S-methyl-N-(3-oxo-3-phenyl-propen-1-yl)-N′-phenyl isothiourea (4h)

Yield 95%, m.p. 70–72.5°C (ether).- IR (KBr): ν = 1655 cm^{-1} (C = O), 1622 (C = N).- ^1H NMR: δ = 8.70 (d, 1H, J = 13.18, =CH-N), 7.96 – 7.90 (m, 2H, arom.), 7.56 - 7.03 (m, 6H, arom.), 6.89 (d, 2H, J = 7.90, arom.), 6.29 (d, 1H, J = 13.18, COCH=), 3.37 (s, 3H, NMe), 2.12 (s, 3H, SMe).

$C_{18}H_{18}N_2OS$ (310.42) Calcd. C 69.66 H 5.85 N 9.02

Found C 69.67 H 5.69 N 8.85

N-(p-N ,N -Dimethylanilino)-S-methyl-N-(3-oxo-3-phenyl-propen-1-yl)-N'-phenyl isothiourea (4i)

Yield 99%, m.p. 122–124°C (methanol).- IR (KBr): ν = 1650 cm^{-1}(C = O), 1610 (C = N).- ^1H NMR: δ = 8.54 (d, 1H, J = 13.23, = CH-N), 7.70 (d, 2H, J = 7.46, arom.), 7.43 – 7.22 (m, 5H, arom.), 7.12 (d, 2H, J = 9.0, arom.),7.05 - 6.98 (m, 1 H, arom.), 6.93 (d, 2H, J = 7.29, arom.), 6.72 (d, 2H, J = 9.0, arom.), 5.96 (d, 1H, J = 13.23, =CHCO), 3.01 (s, 6H, NMe_2), 2.0 (s, 3H, SMe).

$C_{25}H_{25}N_3OS$ (415.56) Calcd. C 72.26 H 6.06 N 10.11
Found C 72.13 H 6.16 N 10.17

N-(2-Ethoxycarbonyl-3-oxo-but-1-enyl)-S-methyl-N,N'-diphenyl isothiourea (6)

Yield 18%, m.p. 98–100°C (ether/P.E.).- IR: ν = 1705 cm^{-1}(ester C = O), 1670 (C = O), 1617 (C = N)).- ^1H NMR: δ = 7.89 and 7.68 [2 br. signals, 1H, =CH-N (E- and Z-form)], 7.35 – 6.91 (m, 10H, arom.), 4.20 and 3.72 [q, 2H, J = 7.13 and 7.18, OCH_2 (Z-and E-form)], 2.27 and 2.22 [s, 3H, CH_3CO (Z- and E-form)], 2.17 (s, 3H, SMe), 1.26 and 1.12 [t, 3H, J = 7.12 and 7.15, Me (Z- and E-form)].

$C_{21}H_{22}N_2O_3S$ (382.49) Calcd. C 65.95 H 5.80 N 7.32 S 8.38
Found C 66.11 H 5.83 N 7.18 S 8.34

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