# Synthesis and Reactions of the Thioamide Derivatives of Methyl Vinyl Ketone



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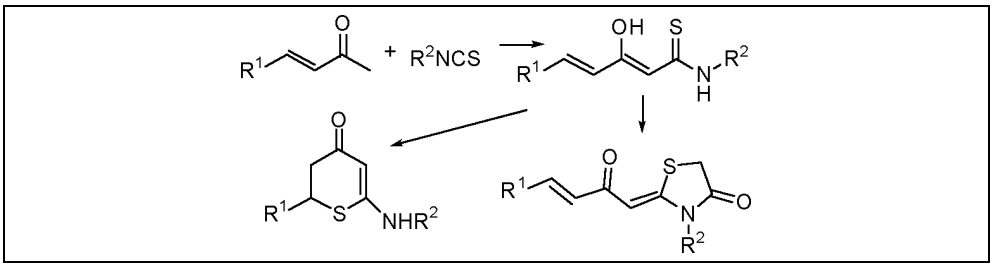


The reaction of isothiocyanates with *in situ* generated carbanions of α,β-unsaturated ketones yielded α,β-unsaturated keto thioamides which in the reaction with acids or bases cyclized to give 2,6-disubstituted thiopyran-4-ones and in the reaction with α-bromoesters gave thiazolidin-4-one derivatives. The thiopyran-4-ones reacted with α,β-unsaturated aldehydes to yield tetrahydrothiopyran[2,3-*b*]pyridin-4-ones, while thioanilides were formed in the reaction with phenyl isothiocyanate.

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## INTRODUCTION

Although thioamides are known almost since the very dawn of organic chemistry, their synthetic applicability has been recognized in full only a few decades ago. High reactivity of the thioamide group towards both electro- and nucleophilic agents, often in conjunction with that of other reactive centers in the molecule, made thioamides handy building blocks of particular importance in the synthesis of heterocyclic systems by inter- and intramolecular cyclization [1].

In many organic compounds, including natural products foremost, one may find a built in fragment of methyl vinyl ketone. The synthesis of acyclic thioamides derived from this ketone is a rather difficult problem because of their instability and ease of spontaneous cyclization. If a reasonably simple and efficient synthetic method is developed, it will certainly come into use as the first step in the synthesis of heterocyclic compounds hardly available using other methods. The development of such method and its application in the synthesis of heterocyclic systems are the main objects of the present research.

Thus far, in the reaction of isothiocyanates with derivatives of methyl vinyl ketone substituted at the methyl with electron acceptor groups 2,3-dihydro-4(*H*)-thiopyran-4-ones were formed, while isolation of the intermediate linear thioamides failed [2]. Moreover, these thiopyranones were substituted at C-5 and therefore, unlike enaminones, could not be used in further transformations. In fact, there is an earlier report on the synthesis of benzylideneacetone thioanilide in the reaction of phenyl isothiocyanate with benzylideneacetone in the presence of sodium *tert*-pentanolate [3], but a completely different thioamide was obtained when duplication of the reaction was attempted in this laboratory.

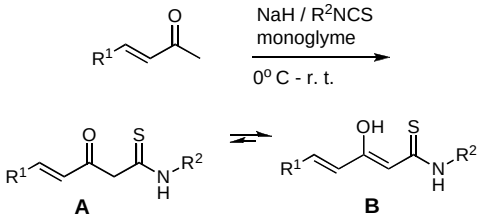
## RESULTS AND DISCUSSION

At first, our investigations were aimed at the preparation of the thioamide derivatives of arylidene-acetones with benzylideneacetone being selected as the most readily available model substrate. In order to prevent addition of benzylideneacetone to its anion, the reaction was carried out by a simultaneous dropwise addition of both reactants to the sodium hydride suspension in monoglyme at 0ºC (Scheme 1). With aromatic isothiocyanates the reaction yields were rather high. Aliphatic and alicyclic isothiocyanates also reacted under these conditions but we encountered serious difficulties in isolation and purification of the products.

In an attempt to define the scope of the reaction we have found that under similar conditions α- and β-ionones reacted with both aliphatic and aromatic isothiocyanates, the yields ranging from satisfactory to good. However, in the case of methyl vinyl ketone the reaction gave a multicomponent mixture whose purification failed; since isolation of a reasonably pure thioamide product proved hardly practicable, no attempts were made to use the mixture in further cyclization reactions.

The linear thioamides **1a-1m** are rather unstable compounds since they cyclize in part on heating. Column chromatography was applied therefore to obtain analytical samples. As shown by 1D nmr ($^1$H, $^{13}$C, $^{13}$C-DEPT), 2D nmr ($^{13}$C, $^1$H COSY) analysis, the enol structure **B** is predominant in solutions.

Scheme 1




**1a - 1m**

| | **1a** | **1b** | **1c** | **1d** | **1e** |
|---|---|---|---|---|---|
| $R^1$ | $C_6H_5$ | $C_6H_5$ | $C_6H_5$ | $C_6H_5$ | α-ionone |
| $R^2$ | $C_6H_4$ | 4-$ClC_6H_4$ | 4-$FC_6H_4$ | 1-naphtyl | $C_6H_5$ |
| yield (%) | 86 | 88 | 91 | 83 | 61 |
| | **1f** | **1g** | **1h** | **1i** | **1j** |
| $R^1$ | α-ionone | α-ionone | α-ionone | β-ionone | β-ionone |
| $R^2$ | $CH_3$ | $C_2H_5$ | cyclo-$C_6H_{11}$ | $C_6H_5$ | $CH_3$ |
| yield (%) | 50 | 76 | 50 | 80 | 59 |
| | **1k** | **1m** | | | |
| $R^1$ | β-ionone | β-ionone | | | |
| $R^2$ | $C_2H_5$ | cyclo-$C_6H_{11}$ | | | |
| yield (%) | 59 | 41 | | | |

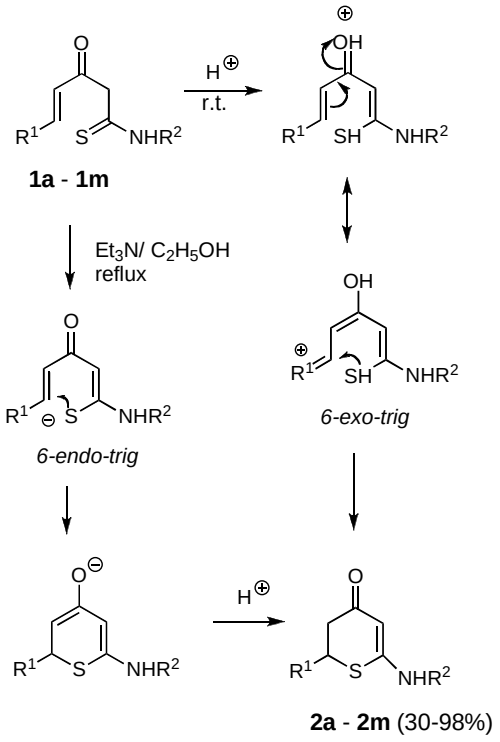
When heated in refluxing ethanol in the presence of triethylamine, the thioamides **1a-m** were slowly converted into 2,6-disubstituted-2,3-dihydrothiopyran-4-ones (**2a-m**). Two days were required to make the conversion complete. It was noted that with magnesium or sodium methoxides only a small part of the thioamide underwent cyclization; this was presumably due to the formation of a chelate structure.

In accord with the Baldwin rules for trigonal systems, the exocyclizations leading to three- and seven-membered rings are favored, whereas the endocyclizations leading to six- and seven-membered rings are only permitted [4]. In our case, the cyclization occurring in an alkaline medium is an intramolecular Michael addition following the 6-endo-trigonal mechanism. However, if one changes the alkaline catalyst to an acidic one, the cyclization process takes the more favored 6-exo-trigonal reaction path (Scheme 2).

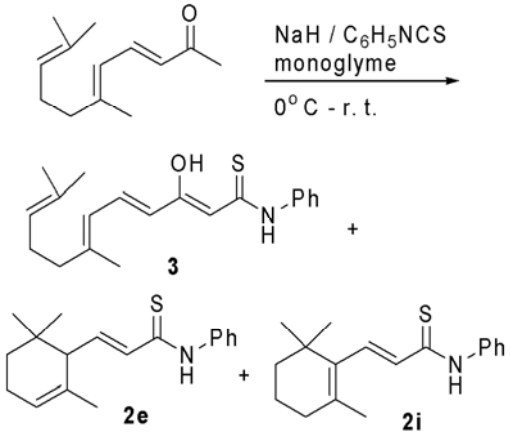
This hypothesis was confirmed experimentally since cyclization in refluxing benzene in the presence of *p*-toluenesulfonic acid occurred swiftly (1 hour) although hardly removable by-products were formed. There was no such problem when the cyclization catalyst was boron trifluoride in acetic acid; the cyclization was then practically quantitative within approximately five minutes.

The developed method was also tested in the synthesis of polyene keto thioamides. Pseudoionone reacted with phenyl isothiocyanate in the presence of sodium hydride in monoglyme to yield a mixture of linear and cyclic products. As found by nmr, pseudoionone thioanilide **3** was the main product but the thioanilides of α- and β-ionones were also formed in appreciable quantities (**3**:**2e**:**2i** as 34:2:64).

Scheme 2




Scheme 3

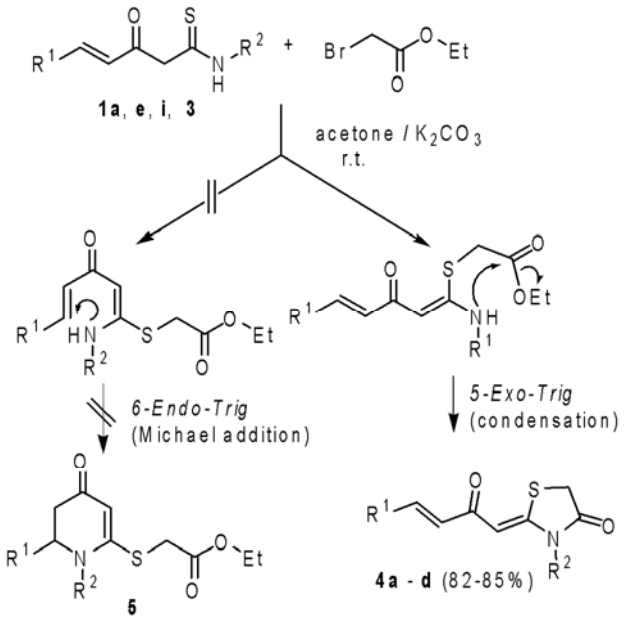



As it has been proven while investigating the synthesis of carotenoids, the cyclization of similar polyene substrates is a proton addition-elimination process. It is initiated by addition of a proton to C-2 at the terminal double bond with the formation of a "carbocation" [5] and a following elimination of the $H_a$, $H_b$, or $H_c$ protons. This

reaction sequence leads to the formation of the appropriate rings.

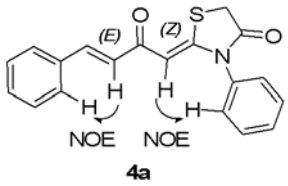
The reactions of thioamides **1a, 1e**, **1i**, and **3** with ethyl bromoacetate may serve as another example of cyclizations following the Baldwin rules. Theoretically, two products might have been expected: the derivatives of tetrahydropyridin-2-one (**5**) generated in a Michael addition process, and the derivatives of thiazolidin-4-one (**4a-c**) formed in the condensation reaction. Only the latter were obtained in our experiments, this reaction course being in agreement with the preference of the 5-exo-trigonal cyclization. Similar reactions of bromoacetic esters with β-keto thioamides have been investigated by us earlier [5]. In the reaction with ethyl bromoacetate, the chromatographically purified linear thioamide **3** yielded a pseudoionone derivative of thiazolidin-4-one **4d**. By analogy to carotenoids [5], a concomitant cyclization of the polyene fragment of pseudoionone might be expected to occur and result in the formation of the α- and β-ionone structures. However, this cyclization was not observed in our case.

Scheme 4




The $^1$H, $^1$H NOESY nmr technique has been recently found as a useful tool for determining the configuration and conformation [6,7,9]. The same technique is applied now to make the stereochemical assignments in the 2-oxodimethylidene moiety of **4a**. The correlation observed in the $^1$H, $^1$H NOESY spectra of **4a** made it possible to estimate the through-space interactions between the following protons or proton groups: =CH vs. $C_6H_5N$, =CH vs. $C_6H_5$ (Figure 1). There is every reason to assume that the α- and β-ionone derivatives **4b**,**c** have an analogous configuration.

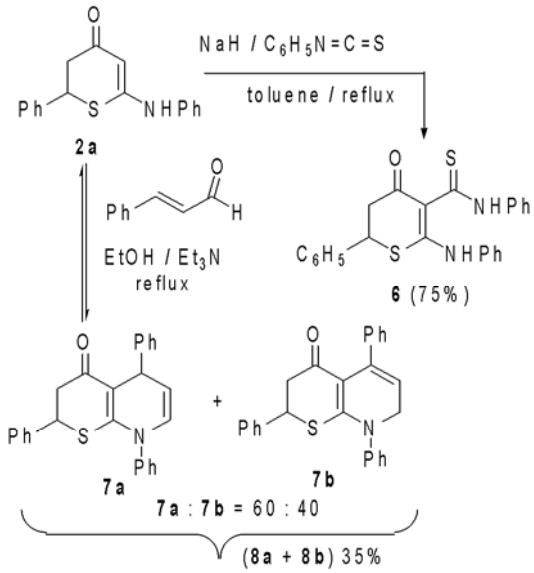
Figure 1




The thiopyran-4-ones **2a** may be also used in further transformations. As in the case of enaminones [8], **2a** has to be at first deprotonated with the aid of sodium hydride, but isothiocyanates attack the ring C-5, not the nitrogen atom (**6**, Scheme 5). No reaction takes place in the absence of sodium hydride. With α,β-unsaturated aldehydes, **2a** react in the same manner as the linear β-keto thioamides; bicyclic structures are formed (*e.g.*, **7a**, **b**) [9]. However, contrary to earlier findings [9], the addition-cyclization process of **2a** with cinnamic aldehyde is irreversible owing to the concomitant dehydration (Scheme 5). A mixture of isomeric tetrahydrothiopyrano-[2,3-*b*]pyridin-4-ones **7a**, **b** (3:2 ratio) results.

The present investigation reveals that both thioamides **1a**-**m** and cyclic thiopyranones **2a**-**m** can be prepared with great ease. Moreover, their reactivity is high enough to make them interesting substrates for further synthetic transformations. The examples presented here serve only as an indication of this synthetic potential.

Scheme 5




## EXPERIMENTAL

Melting points were determined on a digital apparatus Electrotermal model IA9300 and are uncorrected. The $^1$H- and

$^{13}$C-nmr spectroscopic measurements and 1D-$^{13}$C-nmr and 2D-$^{1}$H, $^{1}$H (COSY, NOESY) were performed in deuteriochloroform and deuteriodimethylsulfoxide on a Bruker DPX apparatus (400 MHz) spectrometer with tetramethysilane as the internal standard. The IR spectra were taken with Specord M80 instruments in potassium bromide pellets. Purity and molecular mass determinations were carried out by gas chromatography-mass spectrometry (GC/MS) on a Hewlett-Packard instrument model HP 6890 equipped with a mass detector HP 5973. The analytical procedure was developed for a 30m-long capillary column, 0.2 mm in diameter, with methylsiloxane modified with phenyl groups (5% Ph, Me siloxane) in the 0.25 Xm thick active phase layer. Elemental analyses were performed on EuroEA 3000 series, Euro Vector CHNS-O Elemental Analyser. All compounds gave satisfactory elemental analysis (C, H, N, S). Commercial samples of α-ionone (90%, Aldrich), β-ionone (96%, Aldrich), and pseudoionone (90%, mixture of isomers, Fluka) were used in the experiments.

**General Procedure for Preparation of Thioamides (1a-m).** A solution of the appropriate benzylidene- or alkylideneacetone (10 mmol) and isothiocyanate (12 mmol) in 10 mL of monoglyme was added dropwise under nitrogen to a stirred and cooled (0 °C) suspension of sodium hydride (25 mmol; 80% in mineral oil) in 25 mL of monoglyme. The reaction mixture was then stirred for 2.5 h at room temperature or left standing overnight. The yellow-brown mixture was poured into a dilute (10%) solution of hydrochloric acid with crushed ice and the organic product was extracted with ethyl acetate. After a routine work-up, the crude products were chromatographed in a silica gel-packed column using the *n*-hexane/ethyl acetate (1:1) mixture as the eluent. Recrystallization from an appropriate solvent gave the final products.

**3-Hydroxy-5-phenylpenta-2,4-dienethioic acid phenylamide (1a).** This compound was obtained in 86% yield as yellow crystals; mp 140-143ºC (methanol); ir: 3292 (NH), 1630 (C=C, C-H), 1522 (NH, C-N), 1400 (O-H, C-O), 1318 (C-N), 1208 (NCS) cm$^{-1}$; $^{1}$H nmr (deuteriodimethylsulfoxide): – *enol form*, δ 6.00 (s, 1H, C*H*=COH), 6.75 (d, 1Hd, PhCH=C*H*, J=15.8 Hz), 7.32-7.77 (m, 10H, 2Ph), 7.61 (d, 1H, PhC*H*=CH, J=7.62 Hz), 11.40 (s, 1H, NH), 14.26 (s, 1H, OH). $^{13}$C nmr (deuteriodimethylsulfoxide): δ 103.90 (*C*HCOH), 124.68, 128.26, 129.10, 129.35, 135.71, 138.82 (Ph), 129.83 (PhCH=*C*H), 135.88 (Ph*C*H=CH), 167.04 (C-OH), 189.72 (C=S). $^{1}$H nmr (deuteriodimethylsulfoxide): – *ketone form*, δ 4.30 (s, 2H, COCH$_2$CS), 6.99 (d, 1H, PhCH=C*H*, J=16.22 Hz), 7.32-7.77 (m, 10H, 2Ph), 7.86 (d, 1H, PhC*H*=CH, J=7.73 Hz), 11.80 (s, 1H, NH). *Anal.* Calcd. for $C_{17}H_{15}NOS$ (281.38): C, 72.57; H, 5.37; N, 4.98; S, 11.40. Found: C, 72.11, H, 5.23; N, 4.95; S, 11.72.

**3-Hydroxy-5-phenylpenta-2,4-dienethioic acid (4-chlorophenyl)amide (1b).** This compound was obtained in 88% yield as yellow crystals; mp 160-163ºC (methanol); ir: 3252 (NH), 1632 (C=C, C-H), 1540 (NH, C-N), 1390 (OH, C-O), 1334 (C-N), 1210 (NCS) cm$^{-1}$.$^{1}$H nmr (deuteriodimethylsulfoxide): – *enol form*, δ 5.98 (s, 1H, C*H*=COH), 6.76 (d, 1H, PhCH=C*H*, J=15.47 Hz), 7.29 (d, 1H, PhC*H*=CH, J=6.24 Hz), 7.30-7.54 (m, 4H, 2Ph), 7.55-7.73 (m, 5H, 2Ph), 11.44 (s, 1H, NH), 14.18 (s, 1H, OH). $^{13}$C nmr (deuteriodimethylsulfoxide): δ 103.93 (*C*HCOH), 124.86, 128.30, 129.07, 129.35, 135.66, 137.33 (Ph), 129.91 (PhCH=*C*H), 136.16 (Ph*C*H=CH), 167.38 (C-OH), 189.92 (C=S). $^{1}$H nmr (deuteriodimethylsulfoxide): – *ketone form*, δ 4.29 (s, 2H, CH$_2$CS), 6.82 (d, 1H, PhCH=C*H*, J=15.87 Hz), 7.30-7.54 (m, 4H, 2Ph), 7.55-7.73 (m, 5H, 2Ph), 7.91 (d, 1H, PhC*H*=CH, J=8.83 Hz), 11.87 (s, 1H, NH). *Anal.* Calcd. for $C_{17}H_{14}ClNOS$ (315.82): C, 64.65; H, 4.47; N, 4.43; S, 10.15. Found: C, 64.42; H, 4.46; N, 4.30; S, 10.03.

**3-Hydroxy-5-phenylpenta-2,4-dienethioic acid (4-fluorophenyl)amide (1c).** This compound was obtained in 91% yield as yellow crystals; mp 153-156ºC (methanol); ir: 3200 (NH), 1632 (C=C, C-H), 1518 (NH, C-N), 1388 (OH, C-O), 1316 (C-N), 1208 (NCS) cm$^{-1}$. $^{1}$H nmr (deuteriodimethylsulfoxide): – *enol form*, δ 6.07 (s, 1H, C*H*=COH), 6.88 (d, 1H, PhCH=C*H*, J=15.41 Hz), 7.34 (d, 1H, PhC*H*=CH, J=6.52 Hz), 7.36-7.60 (m, 4H, 2Ph), 7.61-7.86 (m, 5H, 2Ph), 11.49 (s, 1H, NH), 14.29 (s, 1H, OH). $^{13}$C nmr (deuteriodimethylsulfoxide): δ 103.65 (*C*HCOH), 125.04 128.25, 129.33, 129.85, 135.03, 138.96 (Ph), 129.91 (PhCH=*C*H), 135.68 (Ph*C*H=CH), 167.09 (C-OH), 190.00 (C=S). $^{1}$H nmr (deuteriodimethylsulfoxide): – *ketone form*, δ 4.30 (s, 2H, CH$_2$CS), 6.87 (d, 1H, PhCH=C*H*, J=16.02 Hz), 7.31-7.51 (m, 4H, 2Ph), 7.54-7.75 (m, 5H, 2Ph), 7.88 (d, 1H, PhC*H*=CH, J=8.74 Hz), 11.84 (s, 1H, NH). *Anal.* Calcd. for $C_{17}H_{14}FNOS$ (299.37): C, 68.21; H, 4.71; N, 4.68; S, 10.71. Found: C, 68.03; H, 4.62; N, 4.55; S, 11.52.

**3-Hydroxy-5-phenylpenta-2,4-dienethioic acid naphthalen-2-ylamide (1d).** This compound was obtained in 83% yield as yellow crystals; mp 129-132ºC (cyclohexane); ir: 3232 (NH), 1626 (C=C, C-H), 1500 (NH, C-N), 1394 (OH, C-O), 1326 (C-N), 1208 (NCS) cm$^{-1}$; $^{1}$H nmr (deuteriodimethylsulfoxide): – *enol form*, δ 5.89 (s, 1H, C*H*=CHOH), 6.14-6.52 (m, 1H, PhCH=C*H*), 7.16 (d, 1H, PhC*H*=CH, J=6.31 Hz), 7.18-7.56 (m, 8H, Ph, naphth.), 7.57-7.71 (m, 5H, Ph, naphth.), 14.26 (s, 1H, OH); $^{13}$C nmr (deuteriochloroform): δ 98.68 (*C*H=COH), 123.49, 124.61, 125.32, 128.42, 128.58, 128.66, 128.92, 129.00, 135.69, 137.87 (Ph, naphth.), 130.97 (PhCH=*C*H), 144.81 (Ph*C*H=CH), 162.07 (COH), 190.38 (C=S). $^{1}$H nmr (deuteriochloroform): – *ketone form*, δ 4.33 (s, 2H, CH$_2$C=S), 6.91 (d, 1H, PhCH=C*H*, J=16.77 Hz), 7.14-7.56 (m, 8H, Ph, naphth.), 7.58-7.71 (m, 5H, Ph, naphth.), 7.82 (d, 1H, PhC*H*=CH), J=7.20 Hz), 10.45 (s, 1H, NH). *Anal.* Calcd. for $C_{21}H_{17}NOS$ (333.44): C, 76.10; H, 5.17; N, 4.23; S, 9.67. Found: C, 76.03; H, 5.02; N, 4.15; S, 9.52.

**3-Hydroxy-5-(2,6,6-trimethylcyclohex-2-enyl)-penta-2,4-dienethioic acid phenylamide (1e).** This compound was obtained in 61% yield as yellow crystals; mp 125-127ºC (hexane/benzene); ir: 3304 (NH), 2970-2880 (OH···S=C, C-H), 1642 (C=C, C-H), 1586 (C=C), 1526 (NH, C-N), 1400 (OH, C-O), 1322 (C-N), 1208 (NCS) cm$^{-1}$. $^{1}$H nmr (deuteriodimethylsulfoxide): – *enol form*, δ 0.80 (s, 3H, CH$_3$), 0.88 (s, 3H, CH$_3$), 1.10-1.23 (m, 1H, =CHCH$_2$C*H*H), 1.30-1.43 (m, 1H, =CHCH$_2$CH*H*), 1.52 (s, 3H, CH$_3$), 1.94-2.03 (m, 2H, =CHC*H*$_2$CHH), 2.34 (d, 1H, C*H*CH=CH, J=9.62 Hz), 5.46 (s, 1H, C=CHCH$_2$), 5.81 (s, 1H, C*H*=COH), 5.90 (d, 1H, C=C*H*COH, J=15.21 Hz), 6.37 (dd, 1H, CHC*H*=CH, J=15.21, 9.94 Hz), 7.30-7.52 (m, 3H, Ph), 7.58 (d, 2H, Ph, J=7.78 Hz), 11.25 (s, 1H, NH), 14.11 (s, 1H, OH). $^{13}$C nmr (deuteriodimethylsulfoxide): δ 22.87 (CH$_3$), 23.00 (=CCH$_2$), 26.95 (CH$_3$), 27.04 (CH$_3$), 31.33 (CHCH$_2$CH$_2$), 32.58 (CH$_2$CH$_2$*C*), 53.98 (*C*HCH=CH), 102.29 (*C*H=COH), 122.11 (CH=*C*HCH$_2$), 128.36 (CH=*C*HCOH), 131.17 (*C*H=CHCOH), 132.93 (CH$_3$*C*=CH), 124.54, 126.55, 129.01, 138.79 (Ph), 166.73 (COH), 189.97 (C=S). $^{1}$H nmr (deuteriodimethylsulfoxide): – *ketone form,* δ 0.84 (s, 3H, CH$_3$), 0.87 (s, 3H, CH$_3$), 1.10-1.23 (m, 1H, =CHCH$_2$C*H*H), 1.30-1.43 (m, 1H, =CHCH$_2$CH*H*), 1.49 (s, 3H, CH$_3$), 1.94-2.03 (m, 2H, =CHC*H*$_2$CHH), 2.34 (d, 1H,

C*H*CH=CH, J=9.62 Hz), 4.20 (s, 2H, $CSCH_2CO$), 5.46 (s, 1H, C=C*H*$CH_2$), 6.13 (d, 1H, C=C*H*CO, J=15.81 Hz), 6.71 (dd, 1H, CHC*H*=CH, J=15.81, 9.85 Hz), 7.30-7.52 (m, 3H, Ph), 7.81 (d, 2H, Ph, J=7.78 Hz), 11.76 (s, 1H, NH). $^{13}$C nmr (deuteriodimethylsulfoxide): δ 22.87 ($CH_3$), 23.08 (=$CCH_2$), 26.77 ($CH_3$), 27.94 ($CH_3$), 31.14 (=CHC$H_2$C$H_2$), 32.86 ($CH_2CH_2C$), 53.89 (*C*HCH=CH), 58.72 ($CH_2CS$), 122.70 (C=*C*H$CH_2$), 132.19 ($CH_3C$=CH), 139.83 (CH=*C*HCO), 123.27, 126.55, 129.08, 140.48 (Ph), 149.34 (*C*H=CHCO), 193.63 (C=O), 195.14 (C=S). *Anal*. Calcd. for $C_{20}H_{25}NOS$ (327.48): C, 73.35; H, 7.96; N, 4.28; S, 9.79. Found: C, 73.03; H, 7,45; N, 4.15; S, 10.16.

**3-Hydroxy-5-(2,6,6-trimethylcyclohex-2-enyl)-penta-2,4-dienethioic acid methylamide (1f).** This compound was obtained in 50% yield as yellow crystals (hexane/benzene); mp 119-121ºC (hexane/benzene); ir: 3256 (NH), 3000-2860 (OH···S=C, C-H), 1638 (C=C, C-H), 1586 (C=C), 1550 (NH, C-N), 1388 (OH, C-O), 1326 (C-N), 1232 (NCS) $cm^{-1}$. $^1$H nmr (deuteriochloroform): – *enol form*, δ 0.67 (s, 3H, $CH_3$), 0.75 (s, 3H, $CH_3$), 0.95-1,17 (m, 1H, C*H*HC$(CH_3)_2$), 1.21-1.40 (m, 1H, CH*H*C$(CH_3)_2$), 1.38 (s, 3H, $CH_3$), 1.87 (s, 2H, =$CCH_2$), 2.07 (d, 1H, C*H*-CH=CH, J=9.08 Hz), 2.95 (s, 3H, $NCH_3$), 5.16 (s, 1H, C*H*=COH), 5.28 (s, 1H, C*H*=$CCH_3$), 5.53 (d, 1H, CH-CH=C*H*, J=14.94 Hz), 6.30-6.47 (m, 1H, CH-C*H*=CH), 6.95 (s, 1H, NH), 14.07 (s, 1H, OH). $^{13}$C nmr (deuteriochloroform): δ 22.95 (=C*C*$H_3$), 23.05 (=CH*C*$H_2$), 26.92 ($CH_3$), 27.71 ($CH_3$), 30.82 ($NCH_3$), 31.29 (*C*$H_2$C$(CH_3)_2$), 32.62 (*C*$(CH_3)_2$), 54.41 (*C*H-CH=CH), 100.51 (*C*H=COH), 121.99 (*C*H=$CCH_3$), 127.50 (CH-CH=*C*H), 130.52 (CH*C*H=CH), 132.70 (=*C*$CH_3$), 166.32 (=COH), 196.21 (C=S). $^1$H nmr (deuteriochloroform): – *ketone form*, δ 0.67 (s, 3H, $CH_3$), 0.75 (s, 3H, $CH_3$), 0.95-1,17 (m, 1H, C*H*HC$(CH_3)_2$), 1.21-1.40 (m, 1H, CH*H*C$(CH_3)_2$), 1.38 (s, 3H, $CH_3$), 1.87 (s, 2H, =$CCH_2$), 2.14 (d, 1H, C*H*-CH=CH, J=9.31 Hz), 3.02 (s, 3H, $NCH_3$), 3.92 (dd, 2H, $CH_2CS$, J=17.35, 9.93 Hz), 5.35 (s, 1H, C*H*=$CCH_3$), 5.92 (d, 1H, CH-CH=C*H*, J=15.86 Hz), 6.71 (dd, 1H, CH-C*H*=CH, J=15.06, 8.97 Hz), 9.22 (s, 1H, NH). $^{13}$C nmr (deuteriochloroform): δ 22.79 (=C*C*$H_3$), 22.99 (=CH*C*$H_2$), 26.72 ($CH_3$), 27.95 ($CH_3$), 31.00 (*C*$H_2$C$(CH_3)_2$), 32.72 (*C*$(CH_3)_2$), 33.09 ($NCH_3$), 53.39 (*C*$H_2$C=S), 54.55 (*C*H-CH=CH), 123.28 (*C*H=$CCH_3$), 132.70 (=*C*$CH_3$), 141.04 (CH-CH=*C*H), 152.64 (CH*C*H=CH), 192.44 (C=S), 195.51 (C=O). *Anal*. Calcd. for $C_{15}H_{23}NOS$ (265.42): C, 67.88; H, 8.37; N, 5.28; S, 12.08. Found: C, 68.02; H, 8.38; N, 5.49; S, 11.15.

**3-Hydroxy-5-(2,6,6-trimethylcyclohex-2-enyl)-penta-2,4-dienethioic acid ethylamide (1g).** This compound was obtained in 76% yield as yellow crystals; mp 113-115ºC (hexane/benzene); ir: 3288 (NH), 3000-2860 (OH···S=C, C-H), 1638 (C=C, C-H), 1586 (C=C), 1536 (NH, C-N), 1406 (OH, C-O), 1328 (C-N), 1222 (NCS) $cm^{-1}$. $^1$H nmr (deuteriochloroform): – *enol form*, δ 0.78 (s, 3H, $CH_3$), 0.86 (s, 3H, $CH_3$), 1.09-1.23 (m, 4H, C*H*HC$(CH_3)_2$, $CH_2CH_3$), 1.28-1.46 (m, 1H, CH*H*C$(CH_3)_2$), 1.48 (s, 3H, $CH_3$), 1.98 (s, 2H, =CHC$H_2$), 2.17 (d, 1H, C*H*-CH=CH, J=9.79 Hz), 3.50-3.71 (m, 2H, $CH_2CH_3$), 5.20 (s, 1H, C*H*=COH), 5.39 (s, 1H, C*H*=$CCH_3$), 5.62 (d, 1H, CH-CH=C*H*, J=15.30 Hz), 6.46 (dd, 1H, CH-C*H*=CH, J=15.17, 9.68 Hz), 6.65 (s, 1H, NH), 13.82 (s, 1H, OH). $^{13}$C nmr (deuteriochloroform): δ 13.62 ($CH_2CH_3$), 22.94 (=C*C*$H_3$), 23.06 (=CH*C*$H_2$), 26.93 ($CH_3$), 27.70 ($CH_3$), 31.30 (*C*$H_2$C$(CH_3)_2$), 32.65 (*C*$(CH_3)_2$), 38.66 (*C*$H_2CH_3$), 54.44 (*C*H-CH=CH), 100.57 (*C*H=COH), 121.99 (*C*H=$CCH_3$), 127.56 (CH-CH=*C*H), 130.53 (CH*C*H=CH), 132.74 (=*C*$CH_3$), 166.67 (=COH), 196.33 (C=S). $^1$H nmr (deuteriochloroform): – *ketone form*, δ 0.78 (s, 3H, $CH_3$), 0.86 (s, 3H, $CH_3$), 1.09-1.23 (m, 4H, $CH_2CH_3$, C*H*HC$(CH_3)_2$), 1.28-1.46 (m, 1H, CH*H*C$(CH_3)_2$), 1.48 (s, 3H, $CH_3$), 1.98 (s, 2H, =CHC$H_2$), 2.24 (d, 1H, C*H*-CH=CH, J=9.77 Hz), 3.50-3.71 (m, 2H, C$H_2CH_3$), 4.01 (d, 2H, $CH_2CS$, J=10.48 Hz), 5.46 (s, 1H, C*H*=$CCH_3$), 6.01 (d, 1H, CH-CH=C*H*, J=15.73 Hz), 6.82 (dd, 1H, CH-C*H*=CH, J=15.71, 9.75 Hz), 9.20 (s, 1H, NH). $^{13}$C nmr (deuteriochloroform): δ 13.00 ($CH_3$), 22.78 (=C*C*$H_3$), 22.99 (=CH*C*$H_2$), 26.73 ($CH_3$), 27.94 ($CH_3$), 31.02 (*C*$H_2$C$(CH_3)_2$), 32.73 (*C*$(CH_3)_2$), 41.14 (*C*$H_2CH_3$), 53.56 (*C*$H_2$C=S), 54.59 (*C*H-CH=CH), 123.28 (*C*H=$CCH_3$), 132.74 (=*C*$CH_3$), 141.06 (CH-CH=*C*H), 152.61 (CH*C*H=CH), 191.41 (C=S), 194.20 (C=O). *Anal*. Calcd. for $C_{16}H_{25}NOS$ (279.45): C, 68.77; H, 9.02; N, 5.01; S, 11.47. Found: C, 69.10; H, 9.50; N, 5.09; S, 11.30.

**3-Hydroxy-5-(2,6,6-trimethylcyclohex-2-enyl)-penta-2,4-dienethioic acid cyclohexylamide (1h).** This compound was obtained in 50% yield as yellow crystals; mp 119-121ºC (hexane/benzene); ir: 3320 (NH), 3000-2860 (OH···S=C, C-H), 1646 (C=C, C-H), 1594 (C=C), 1528 (NH, C-N), 1408 (OH, C-O), 1328 (C-N), 1214 (NCS) $cm^{-1}$; $^1$H nmr (deuteriochloroform): – *enol form*, δ 0.84 (s, 3H, $CH_3$), 0.91 (s, 3H, $CH_3$), 1.17-1.50 (m, 6H, C$H_2$C$(CH_3)_2$, $2CH_2$-cyclo), 1.55 (s, 3H, =$CCH_3$), 1.57-1.81 (m, 4H, $2CH_2$-cyclo), 1.95-2.13 (m, 4H, =CHC$H_2$, $CH_2$-cyclo), 2.23 (d, 1H, C*H*CH=CH, J=9.71 Hz), 4.23-4.47 (m, 1H, CH-cyclo), 5.25 (s, 1H, C*H*=COH), 5.45 (s, 1H, C*H*=$CCH_3$), 5.68 (d, 1H, CH-CH=C*H*, J=15.19 Hz), 6.51 (dd, 1H, CH-C*H*=CH, J=15.16, 9.67 Hz), 6.64 (s, 1H, NH), 13.95 (s, 1H, OH). $^{13}$C nmr (deuteriochloroform): δ 22.94 (=C*C*$H_3$), 23.06 (=CH*C*$H_2$), 24.73, 25.46 ($CH_2$-cyclo), 26.92 ($CH_3$), 27.70 ($CH_3$), 31.00 (*C*$H_2$C$(CH_3)_2$), 31.28 ($CH_2$-cyclo), 32.64 (*C*$(CH_3)_2$), 54.22 (CH-cyclo), 54.42 (*C*H-CH=CH), 100.84 (*C*H=COH), 121.97 (*C*H=$CCH_3$), 127.63 (CH-CH=*C*H), 130.45 (CH*C*H=CH), 132.74 (=*C*$CH_3$), 166.68 (=COH), 196.41 (C=S). $^1$H nmr (deuteriochloroform): – *ketone form*, δ 0.85 (s, 3H, $CH_3$), 0.92 (s, 3H, $CH_3$), 1.17-1.50 (m, 6H, C$H_2$C$(CH_3)_2$, $2CH_2$-cyclo), 1.55 (s, 3H, =$CCH_3$), 1.57-1.81 (m, 4H, $2CH_2$-cyclo), 1.95-2.13 (m, 4H, =CHC$H_2$, $CH_2$-cyclo), 2.31 (d, 1H, C*H*CH=CH, J=9.82 Hz), 4.05 (s, 2H, $CH_2CS$), 4.23-4.47 (m, 1H, CH-cyclo), 5.52 (s, 1H, C*H*=$CCH_3$), 6.07 (d, 1H, CH-CH=C*H*, J=15.70 Hz), 6.88 (dd, 1H, CH-C*H*=CH, J=15.72, 9.76 Hz), 9.24 (s, 1H, NH). $^{13}$C nmr (deuteriochloroform): δ 22.78 (=C*C*$H_3$), 22.99 (=CH*C*$H_2$), 24.39, 25.46 ($CH_2$-cyclo), 26.27 ($CH_3$), 27.95 ($CH_3$), 31.10 ($CH_2$C$(CH_3)_2$), 32.05 ($CH_2$-cyclo), 32.71 (*C*$(CH_3)_2$), 51.85 (CH-cyclo), 53.79 (*C*$H_2$C=S), 54.57 (*C*H-CH=CH), 123.25 (*C*H=$CCH_3$), 131.20 (=*C*$CH_3$), 140.90 (CH-CH=*C*H), 152.51 (CH*C*H=CH), 190.62 (C=S), 192.70 (C=O). *Anal*. Calcd. for $C_{20}H_{31}NOS$ (333.54): C, 72.02; H, 9.37; N, 4.20; S, 9.61. Found: C, 72.12; H, 9.48; N, 4.27; S, 9.47

**3-Hydroxy-5-(2,6,6-trimethylcyclohex-1-enyl)-penta-2,4-dienethioic acid phenylamide (1i).** This compound was obtained in 80% yield as yellow crystals; mp 105-107ºC (hexane/benzene); ir: 3344(NH), 2970-2880 (OH···S=C, C-H), 1624 (C=C, C-H), 1580 (C=C), 1496 (NH, C-N), 1406 (OH, C-O), 1320 (C-N), 1206 (NCS) $cm^{-1}$; $^1$H nmr (deuteriochloroform): – *enol form*, δ 1.05 (s, 6H, $2CH_3$), 1.42-1.55 (m, 2H, *C*$H_2$C$(CH_3)_2$), 1.56-1.67 (m, 2H, =CHC$H_2$C$H_2$), 1.74 (s, 3H, $CH_3$), 2.04 (s, 2H, =C-$CH_2$), 5.60 (s, 1H, *C*H=C-OH), 5.73 (d, 1H, =C-CH=*C*H, J=15.24 Hz), 7.04-7.32 (m, 3H, Ph), 7.33-7.57 (m, 2H, Ph), 7.64 (d, 1H, =C-*C*H=CH, J=16.30 Hz), 8.25 (s, 1H, NH), 14.26 (s, 1H, OH). $^{13}$C nmr (deuteriochloroform): δ 13.61 ($CH_2$*C*$H_3$), 19.02 (=$CCH_2$*C*$H_2$), 21.85 (=C*C*$H_3$), 28.91 ($CH_3$), 33.52 (=C*C*$H_2$), 34.23 (*C*$(CH_3)_2$), 39.71 (*C*$H_2$C$(CH_3)_2$), 100.52 (*C*H=C-OH), 125.23, 129.44, 138.72 (Ph), 128.00 (=C-

CH=*CH*), 134.20 (=*C*$CH_3$), 136.77 (C-*CH*=CH), 137.83 (=*C*-CH=CH), 166.93 (=C-OH), 196.86 (C=S). $^1$H nmr (deuteriochloroform): – ketone *form*, δ 1.12 (s, 6H, $2CH_3$), 1.45-1.55 (m, 2H, $CH_2C(CH_3)_2$), 1.56-1.67 (m, 2H, =$CHCH_2CH_2$), 1.84 (s, 3H, $CH_3$), 2.13 (s, 2H, =C-$CH_2$), 4.27 (s, 2H, $CH_2C$=S), 6.26 (d, 1H, =C-CH=*CH*, J=16.17 Hz), 7.04-7.32 (m, 4H, Ph, =C-*CH*=CH), 7.33-7.57 (m, 2H, Ph), 11.15 (s, 1H, NH). $^{13}$C nmr (deuteriochloroform): δ 18.74 (=$CCH_2CH_2$), 22.05 (=$CCH_3$), 28.83 ($CH_3$), 33.52 (=$CCH_2$), 34.17 ($C(CH_3)_2$), 39.98 ($CH_2C(CH_3)_2$), 55.91 ($CH_2C$=S), 123.41, 128.87, 138.71 (Ph), 128.64 (=C-CH=*CH*), 136.11 (=*C*-$CH_3$), 140.73 (=*C*-CH=CH), 146.26 (=C-*CH*=CH), 190.71 (C=S), 193.53 (C=O). *Anal*. Calcd. for $C_{20}H_{25}NOS$ (327.49): C, 73.35; H, 7.69; N, 4.28; S, 9.79. Found: C, 73.03; H, 7.70; N, 4.15; S, 9.77.

**3-Hydroxy-5-(2,6,6-trimethylcyclohex-1-enyl)-penta-2,4-dienethioic acid methylamide (1j).** This compound was obtained in 59% yield as yellow crystals; mp 107-110ºC (hexane/benzene); ir: 3264 (NH), 3000-2860 (OH···S=C, C-H), 1638 (C=C, C-H), 1592 (C=C), 1548 (NH, C-N), 1384 (OH, C-O), 1320 (C-N), 1240 (NCS) cm$^{-1}$; $^1$H nmr (deuteriochloroform): – *enol form*, δ 1.05 (s, 6H, $2CH_3$), 1.49 (d, 2H, $CH_2C(CH_3)_2$, J=5.82 Hz), 1.62 (s, 2H, =$CCH_2CH_2$), 1.74 (s, 3H, =$CCH_3$), 2.04 (s, 2H, =$CCH_2$), 3.14 (s, 3H, $NCH_3$), 5.34 (s, 1H, C*H*=COH), 5.72 (d, 1H, =CCH=C*H*, J=16.11 Hz), 7.01 (s, 1H, NH), 7.16 (d, 1H, =CC*H*=CH, J=15.74 Hz), 13.92 (s, 1H, OH). $^{13}$C nmr (deuteriochloroform): δ 19.05 (=$CCH_2CH_2$), 21.76 (=$CCH_3$), 28.88 ($CH_3$), 30.84 ($NCH_3$), 33.38 (=$CCH_2$), 34.19 ($C(CH_3)_2$), 39.66 ($CH_2C(CH_3)_2$), 100.89 (*C*H=COH), 128.04 (=C-CH=*C*H), 133.06 (=*C*$CH_3$), 135.97 (=C-*C*H=CH), 136.79 (=*C*-CH=CH), 166.89 (=COH), 196. 51 (C=S). $^1$H nmr (deuteriochloroform): – *ketone form*, δ 1.09 (s, 6H, $2CH_3$), 1.49 (d, 2H, $CH_2C(CH_3)_2$, J=5.82 Hz), 1.62 (s, 2H, =$CHCH_2CH_2$), 1.82 (s, 3H, =$CCH_3$), 2.11 (s, 2H, =$CCH_2$), 3.21 (s, 3H, $NCH_3$), 4.14 (s, 2H, $CH_2CS$), 6.19 (d, 1H, =C-CH=C*H*, J=16.24 Hz), 7.55 (d, 1H, =CC*H*=CH, J=16.17 Hz), 9.47 (s, 1H, NH). $^{13}$C nmr (deuteriochloroform): δ 18.72 (=$CCH_2CH_2$), 21.98 (=$CCH_3$), 28.78 ($CH_3$), 33.10 ($NCH_3$), 34.07 (=$CCH_2$), 34.11 ($C(CH_3)_2$), 39.91 ($CH_2C(CH_3)_2$), 54.04 ($CH_2C$=S), 128.82 (=CCH=*C*H), 136.01 (=*C*$CH_3$), 140.15 (=*C*CH=CH), 145.84 (=C*C*H=CH), 192.31 (C=S), 195.73 (C=O). *Anal*. Calcd. for $C_{15}H_{23}NOS$ (265.42): C, 67.88; H, 8.37; N, 5.28; S, 12.08. Found: C, 68.55; H, 8.95; N, 5.31; S, 12.00.

**3-Hydroxy-5-(2,6,6-trimethylcyclohex-1-enyl)-penta-2,4-dienethioic acid ethylamide (1k).** This compound was obtained in 50% yield as yellow crystals; mp 107-110ºC (hexane/benzene); ir: 3244 (NH), 3000-2860 (OH···S=C, C-H), 1636 (C=C, C-H), 1584 (C=C), 1544 (NH, C-N), 1406 (OH, C-O), 1324 (C-N), 1226 (NCS) cm$^{-1}$; $^1$H nmr (deuteriochloroform): – *enol form*, δ 1.05 (s, 6H, $2CH_3$), 1.22-1.33 (m, 3H, $CH_3$), 1.41-1.52 (m, 2H, $CH_2C(CH_3)_2$), 1.55-1.64 (m, 2H, =$CHCH_2CH_2$), 1.74 (s, 3H, $CH_3$), 2.04 (t, 2H, =C-$CH_2$, J=5.97 Hz), 3.58-3.72 (m, 2H, $CH_2CH_3$), 5.32 (s, 1H, *CH*=C-OH), 5.72 (d, 1H, =C-CH=*CH*, J=15.82 Hz), 6.82 (s, 1H, NH), 7.15 (d, 1H, =C-*CH*=CH, J=15.83 Hz), 14.29 (s, 1H, OH). $^{13}$C nmr (deuteriochloroform): δ 13.61 ($CH_2CH_3$), 19.04 (=$CCH_2CH_2$), 21.95 (=$CCH_3$), 28.86 ($CH_3$), 34.05 (=$CCH_2$), 34.17 ($C(CH_3)_2$), 39.90 ($CH_2C(CH_3)_2$), 41.15 ($CH_2CH_3$), 101.00 (CH=*C*-OH), 128.09 (=C-CH=*CH*), 133.00 (=*C*-$CH_3$), 135.86 (C-*CH*=CH), 136.78 (=*C*-CH=CH), 167.01 (=C-OH), 196.38 (C=S). $^1$H nmr (deuteriochloroform): – ketone *form*, δ 1.09 (s, 6H, $2CH_3$), 1.22-1.33 (m, 3H, $CH_3$), 1.41-1.52 (m, 2H, $CH_2C(CH_3)_2$), 1.55-1.64 (m, 2H, =$CHCH_2CH_2$), 1.81 (s, 3H, $CH_3$), 2.11 (t, 2H, =C-$CH_2$, J=6.18 Hz), 3.58-3.72 (m, 2H, $CH_2CH_3$), 4.10 (s, 2H, $CH_2C$=S), 6.19 (d, 1H, =C-CH=*CH*, J=16.21 Hz), 7.55 (d, 1H, =C-*CH*=CH, J=16.10 Hz), 9.29 (s, 1H, NH). $^{13}$C nmr (deuteriochloroform): δ 13.01 ($CH_2CH_3$), 18.72 (=$CCH_2CH_2$), 21.73 (=$CCH_3$), 28.76 ($CH_3$), 33.36 (=$CCH_2$), 34.10 ($C(CH_3)_2$), 38.67 ($CH_2CH_3$), 39.65 ($CH_2C(CH_3)_2$), 54.42 ($CH_2C$=S), 128.77 (=C-CH=*CH*), 136.00 (=*C*-$CH_3$), 140.06 (=*C*-CH=CH), 145.76 (=C-*CH*=CH), 191.04 (C=S), 194.42 (C=O). *Anal*. Calcd. for $C_{16}H_{25}NOS$ (279.45): C, 68.77; H, 9.02; N, 5.01; S, 11.7. Found: C, 69.09; H, 9.59; N, 5.06; S, 10.91.

**3-Hydroxy-5-(2,6,6-trimethylcyclohex-1-enyl)-penta-2,4-dienethioic acid cyclohexylamide (1m).** This compound was obtained in 31% yield as yellow crystals; mp 107-110ºC (hexane/benzene); ir: 3316 (NH), 3000-2880 (OH···S=C, C-H), 1638 (C=C, C-H), 1590 (C=C), 1528 (NH, C-N), 1406 (OH, C-O), 1330 (C-N), 1212 (NCS) cm$^{-1}$; $^1$H nmr (deuteriochloroform): – *enol form*, δ 1.04 (s, 6H, $2CH_3$), 1.14-1.53 (m, 6H, $CH_2C(CH_3)_2$, $2CH_2$-cyclo), 1.54-1.67 (m, 4H, =$CCH_2CH_2$, $CH_2$-cyclo), 1.68-1.79 (m, 5H, $CH_2$-cyclo, =$CCH_3$), 1.98-2.15 (m, 4H, $CH_2$-cyclo, =CH-$CH_2$), 4.38 (s, 1H, CH-cyclo), 5.26 (s, 1H, *CH*=C-OH), 5.71 (d, 1H, =C-CH=*CH*, J=15.77 Hz), 6.58 (s, 1H, NH), 7.14 (d, 1H, =C-*CH*=CH J=15.80 Hz), 14.00 (s, 1H, OH); $^{13}$C nmr (deuteriochloroform): δ 19.06 (=$CCH_2CH_2$), 21.71 (=$CCH_3$), 24.73, 25.49 ($CH_2$-cyclo), 28.86 ($CH_3$), 32.10 ($CH_2$-cyclo), 33.36 (=$CCH_2$), 34.12 ($C(CH_3)_2$), 39.67 ($CH_2C(CH_3)_2$), 51.85 (CH-cyclo), 101.23 (CH=*C*-OH), 128.20 (=C-CH=*CH*), 132.87 (=*C*-$CH_3$), 135.85 (C-*CH*=CH), 136.86 (=*C*-CH=CH), 167.19 (=C-OH), 196.59 (C=S); $^1$H nmr (deuteriochloroform): – ketone *form*, δ 1.09 (s, 6H, $2CH_3$), 1.14-1.53 (m, 6H, $CH_2C(CH_3)_2$, $2CH_2$-cyclo), 1.54-1.67 (m, 4H, =$CCH_2CH_2$, $CH_2$-cyclo), 1.68-1.79 (m, 2H, $CH_2$-cyclo), 1.81 (s, 3H, =$CCH_3$), 1.98-2.15 (m, 4H, $CH_2$-cyclo, =CH-$CH_2$), 4.08 (s, 2H, $CH_2C$=S), 4.38 (s, 1H, CH-cyclo), 6.18 (d, 1H, =C-CH=*CH*, J=16.22 Hz), 7.55 (d, 1H,=C-*CH*=CH, J=16.16 Hz), 9.30 (s, 1H, NH); $^{13}$C nmr (deuteriochloroform): δ 18.74 (=$CCH_2CH_2$), 21.95 (=$CCH_3$), 24.42, 25.49 ($CH_2$-cyclo), 28.78 ($CH_3$), 31.14 ($CH_2$-cyclo), 34.03 (=$CCH_2$), 34.19 ($C(CH_3)_2$), 39.91 ($CH_2C(CH_3)_2$), 54.22 (CH-cyclo), 54.59 ($CH_2C$=S), 128.86 (=C-CH=*CH*), 136.05 (=*C*-$CH_3$), 139.88 (*C*-CH=CH), 136.86 (=C-*CH*=CH), 189.71 (C=S), 192.95 (C=O). *Anal*. Calcd. for $C_{20}H_{31}NOS$ (333.54): C, 72.02; H, 9.37; N, 4.20; S, 9.61. Found: C, 72.23; H, 9.98; N, 4.30; S, 9.52.

**3-Hydroxy-7,11-dimethyldodeca-2,4,6,10-tetraenethioic acid phenylamide (3).** This compound was obtained in 65% yield as a dark oil; ir: 3276-3164 (NH, OH), 1738 (C=O), 1612-1556 (C=C-OH, C=C), 1060 (C=S) cm$^{-1}$; $^1$H nmr (deuteriochloroform): – *enol form*, δ 1.86 (s, 6H, $CH_3$), 2.02 (s, 3H, $CH_3$), 2.08-2.25 (m, 4H, $2CH_2$), 4.94-5.04 (m, 1H, =C*H*$CH_2$), 5.60 (s, 1H, C*H*COH), 5.73 (d, 1H, =C*H*COH, J=14.63 Hz), 5.94 (d, 1H, =C*H*CH=, J= 11.27 Hz), 7.14-7.36 (m, 8H, Ph, =CHC*H*=CH), 7.39-7.49 (m, 4H, Ph), 8.12 (br. s, 1H, NH), 14.57 (s, 1H, OH); $^{13}$C nmr (deuteriochloroform): δ 17.47 ($CH_3$), 17.71 ($CH_3$), 25.70 ($CH_3$), 26.39 ($CHCH_2CH_2$), 40.42 ($CH_2CH_2C$), 103.80 (C=COH), 120.48 (=CHCH=), 123.02 (*C*HCOH), 123.74 (C=*C*HCH$_2$), 132.58 (*C*=CHCH$_2$), 123.38, 125.33, 126.81, 137.89 (Ph), 141.03 ($CH_3CCH_2$), 142.90 (*C*=CHCOH), 171.20 (C-OH), 197.13 (C=S); $^1$H nmr (deuteriochloroform) – *ketone form*: δ 1.88 (s, 6H, $CH_3$), 2.02 (s, 3H, $CH_3$), 2.08-2.25 (m, 4H, $2CH_2$), 4.24 (s, 2H, $CH_2CS$), 5.04-5.16 (m, 1H, =C*H*$CH_2$), 6.07 (d, 1H, =C*H*CH=, J=11.27 Hz), 6.15 (d, 1H, =C*H*CO, J=14.94 Hz), 7.14-7.36 (m, 8H, Ph, =CHC*H*=CH), 7.39-7.49 (m, 4H, Ph), 11.21 (br. s, 1H, NH). $^{13}$C nmr (deuteriochloroform): δ 17.71 ($CH_3$), 21.06 ($CH_3$), 25.70 ($CH_3$), 26.95 ($CHCH_2CH_2$),

40.66 ($CH_2CH_2C$), 60.42 ($CH_2CS$), 121.86 (=CHCH=), 124.25 (CHCO), 132.17 (C=$CHCH_2$), 123.48, 125.11, 126,50, 138.73 (Ph), 155.26 (C=CHCOH), 190.54 (C=S), 193.55 (C=O). *Anal.* Calcd. for $C_{20}H_{25}NOS$ (327.48): C, 73.35; H, 7.69; N, 4.28; S, 9.79 Found: C, 73.23; H, 7.65; N, 4.13; S, 10.08.

**General Procedure for Preparation of 3,4-Dihydrothiopyran-4-ones (2a-m). Method A.** Crude thioamide (**1a**-**d**, 5 mmol) was dissolved in 10 mL of ethanol (**1a** and **1c**) or dioxane (**1b** and **1d**), 1.5 mL of triethylamine was added and the mixture was heated for 2 days at 55-60ºC. The solid product was collected by filtration, the filtrate was concentrated, and the residue was treated with 0.5-1 mL of toluene and left in a refrigerator. The precipitate was again collected by filtration, combined with the main portion, and dried in air.

**Method B.** Two mL of a solution of boron trifluoride-diacetic acid complex (36% $BF_3$, Fluka) were added to a stirred solution of the thioamide **1a**-**m** (0.33 mmol) in 2 mL of dry THF and the reaction was monitored by TLC until the substrates disappeared. Upon dilution with water, the organic product was extracted with ethyl acetate and the extract was washed with water and passed under reduced pressure through a 10-cm column packed with $Al_2O_3$. Concentration of the eluate gave crude products which were purified by recrystallization from toluene.

**Cyclization of pseudoionone thioamide (3).** To the solution of crude **3** (4.19 g, 12 mmol) in 30 mL of methylene chloride boron trifluoride etherate (5 mL, 39 mmol, 50%, Merck) were added. The solution was stirred for several h left standing overnight, and finally poured onto crushed ice. After a routing work-up the crude product was chromatographed in a silica gel column with ethyl acetate/*n*-hexane (3:2) as the eluent. The product (3.2 g) was a 34:66 mixture (according to nmr) of thiopyranones **2e** and **2i**.

**2-Phenyl-6-phenylamino-2,3-dihydro-thiopyran-4-one (2a).** This compound was obtained in 54% yield as pale yellow crystals; mp 195-197ºC (toluene); ir: 3212 (NH), 1590 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1444 (C-H), 1262 (NH) $cm^{-1}$; $^1$H-nmr (deuteriodimethylsulfoxide): δ 2.65 (dd, 1H, C*H*H, J=16.16, 2.81 Hz), 3.02 (dd, 1H, CH*H*, J=16.11, 2.98 Hz), 4.77 (dd, 1H, Ph-C*H*, J=12.70, 2.53 Hz), 5.67 (s, 1H, =CH), 7.10 (t, 1H, Ph, J=7.29 Hz), 7.19 (d, 2H, Ph, J=7.99 Hz), 7.26-7.40 (m, 5H, Ph), 7.45 (d, 2H, Ph, J=7.48 Hz), 9.41 (s, 1H, NH); NMR $^{13}$C - nmr (deuteriodimethylsulfoxide) 44.38 ($CH_2$), 45.03 (CH), 98.55 (=CH), 123.53, 125.13, 128.12, 128.58, 129.18, 129.53, 138.76, 139.33 (2Ph), 160.92 (=C), 192.20 (C=O). *Anal.* Calcd. for $C_{17}H_{15}NOS$ (281.38): C, 72.57; H, 5.37; N, 4.98; S, 11.40. Found: C, 72.49; H, 5.29; N, 4.89; S, 11.20.

**6-(4-Chlorophenylamino)-2-phenyl-2,3-dihydrothiopyran-4-one (2b).** This compound was obtained in 70% yield as pale yellow crystals; mp 217-219ºC (toluene); ir: 3184 (NH), 1582 (C=O, C=C), 1550-1492 (NH, C-N, C=C), 1404 (C-H), 1260 (NH) $cm^{-1}$; $^1$H nmr (deuteriodimethylsulfoxide): δ 2.64 (dd, 1H, C*H*H, J=16.25, 2.56 Hz), 3.04 (dd, 1H, CH*H*, J=16.04, 13.05 Hz), 4.84 (d, 1H, CH, J=10.18 Hz), 5.63 (s, 1H, =CH), 7.21 (d, 2H, Ph, J=8.53 Hz), 7.28-7.45 (m, 5H, Ph), 7.50 (d, 2H, Ph, J=7.19 Hz), 9.48 (s, 1H, NH). $^{13}$C nmr (deuteriodimethylsulfoxide): δ 44.22 ($CH_2$), 44.81 (CH), 99.19 (=CH), 124.88, 128.27, 128.92, 129.31, 129.69, 138.42, 138.81 ($C_6H_5$, $C_6H_4$), 160.24 (=C-S), 192.37 (C=O). *Anal.* Calcd. for $C_{17}H_{14}ClNOS$ (315.82): C, 64.65; H, 4.47; N, 4.43; S, 10.15. Found: C, 64.44; H, 4.42; N, 4.29; S, 10.14.

**6-(4-Fluorophenylamino)-2-phenyl-2,3-dihydrothiopyran-4-one (2c).** This compound was obtained in 63% yield as pale yellow crystals; mp 212-214ºC (toluene); ir: 3196 (NH), 1590 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1412 (C-H), 1264 (NH) $cm^{-1}$; $^1$H nmr (deuteriodimethylsulfoxide): δ 2.63 (dd, 1H, C*H*H, J=16.21, 2.79 Hz), 3.04 (dd, 1H, CH*H*, J=16.12, 12.96 Hz), 4.86 (dd, 1H, CH, J=12.63, 2.48 Hz), 5.54 (s, 1H, =CH), 7.13-7.28 (m, 4H, Ph), 7.28-7.43 (m, 3H, Ph), 7.48 (d, 2H, Ph, J=7.28 Hz), 9.39 (s, 1H, NH). $^{13}$C nmr (deuteriodimethylsulfoxide): δ 44.26 ($CH_2$), 44.91 (CH), 98.15 (=CH), 116.39, 116.62, 126.09, 128.26, 128.72, 129.29, 135.54, 138.90 ($C_6H_5$, $C_6H_4$), 158.55 (C-F), 161.16 (=C-S), 192.12 (C=O). *Anal.* Calcd. for $C_{17}H_{14}FNOS$ (299.37): C, 68.21, H, 4.71; N, 4.68; S, 10.71. Found: C, 68.04; H, 4.51; N, 4.54; S, 10.65.

**6-(Naphthalen-1-ylamino)-2-phenyl-2,3-dihydrothiopyran-4-one (2d).** This compound was obtained in 50% yield as pale yellow crystals; mp 197-199ºC (toluene); ir: 3192 (NH), 1590 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1394 (C-H), 1266 (NH) $cm^{-1}$; $^1$H nmr (deuteriodimethylsulfoxide): δ 2.75 (dd, 1H, C*H*H, J=16.29, 2.92 Hz), 2.93-3.09 (m, 1H, CH*H*), 4.76 (dd, 1H, CH, J=13.24, 2.76 Hz), 5.42 (s, 1H, =CH), 7.30-7.51 (m, 6H, Ph, naphth.), 7.52-7.58 (m, 2H, Ph, naphth.), 7.80 (d, 2H, naphth., J=8.05 Hz), 7.85-7.92 (m, 1H, naphth.), 9.37 (s, 1H, NH). $^{13}$C nmr (deuteriodimethylsulfoxide): δ 44.27 ($CH_2$C=O), 44.89 (SCH), 98.59 (=CHC=O), 115.06, 115.86, 124.78, 125.36, 128.32, 128.74, 129.36, 130.27, 137.48, 139.52 (Ph, naphth.), 160.82 (=C-NH), 192.35 (C=O). *Anal.* Calcd. for $C_{21}H_{17}NOS$ (333.44): C, 76.10; H, 5.17; N, 4.23; S, 9.67. Found: C, 76.07; H, 5.14; N, 4.12; S, 9.37.

**6-Phenylamino-2-(2,6,6-trimethylcyclohex-2-enyl)-2,3-dihydrothiopyran-4-one (2e).** This compound was obtained in 90% yield as pale yellow crystals; mp 193-197ºC (heptane/toluene); ir: 3400 (NH), 1608 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1252 (NH) $cm^{-1}$; $^1$H nmr (deuteriodimethylsulfoxide): δ 0.84 (s, 3H, $CH_3$), 0.95 (s, 3H, $CH_3$), 1.12-1.17 (m, 1H, C*H*HC$(CH_3)_2$), 1.56 (dd, 1H, CH*H*C$(CH_3)_2$, J=22.44, 9.32 Hz), 1.69 (s, 1H, =CCH), 1.81 (s, 3H, =C$CH_3$), 1.97 (s, 2H, =CHC$H_2$), 2.53 (t, 1H, C*H*HC=O, J=15.75 Hz), 2.87 (t, 1H, CH*H*C=O, J=15.55 Hz), 3.80 (d, 1H, SCH, J=14.12 Hz), 5.48 (s, 1H, =C*H*$CH_2$), 5.72 (s, 1H, =CHC=O), 7.05-7.10 (m, 3H, Ph), 7.11-7.27 (m, 2H, Ph). $^{13}$C nmr (deuteriochloroform): δ 22.27 (=CH*C*$H_2$), 26.37 (=C$CH_3$), 27.08 ($CH_3$), 28.41 (=C*C*$H_3$), 30.38 (=CHC$H_2$*C*$H_2$), 33.27 (*C*$(CH_3)_2$), 43.53 (SCH), 47.89 ($CH_2$C=O), 53.46 (CH=C*C*H), 99.62 (=CHC=O), 123.34, 125.51, 129.45, 138.30 ($C_6H_5$), 124.76 (=*C*H$CH_2$), 132.29 (CH=*C*CH), 162.35 (CNH), 195.33 (C=O). *Anal.* Calcd. for $C_{20}H_{25}NOS$ (327.49): C, 73.35; H, 7.96; N, 4.28; S, 9.79. Found: C, 73.62; H, 7.68; N, 4.26; S, 9.47.

**6-Methylamino-2-(2,6,6-trimethylcyclohex-2-enyl)-2,3-dihydrothiopyran-4-one (2f).** This compound was obtained in 91% yield as pale yellow crystals; mp 158-161ºC (heptane/ toluene); ir: 3428 (NH), 1608 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1246 (NH) $cm^{-1}$; $^1$H nmr (deuteriochloroform): δ 0.90 (s, 3H, $CH_3$), 1.01 (s, 3H, $CH_3$), 1.13-1.26 (m, 1H, C*H*HC$(CH_3)_2$), 1.51-1.68 (m, 1H, CH*H*C$(CH_3)_2$), 1.73 (s, 1H, =CCH), 1.84 (s, 3H, $CH_3$), 2.02 (s, 2H, =C$CH_2$), 2.58 (d, 1H, C*H*HC=O, J=16.39 Hz), 2.75-2.99 (m, 4H, CH*H*C=O, NHC$H_3$), 3.85 (d, 1H, SCH, J=14.02 Hz), 5.36 (s, 1H, =C*H*$CH_2$), 5.52 (s, 1H, =CHC=O). $^{13}$C nmr (deuteriochloroform): δ 23.23 (C=C*C*$H_2$), 26.34 ($CH_3$), 27.08 ($CH_3$), 28.37 (=C*C*$H_3$), 30.37 (*C*$H_2$C$(CH_3)_2$), 30.88 (N$CH_3$), 33.20 (*C*$(CH_3)_2$), 43.69 (SCH), 47.85 (*C*$H_2$CO), 53.51 (=C*C*H), 95.62 (=*C*C=O), 124.60 (*C*=C$CH_3$), 132.25 (C=*C*$CH_3$), 165.39 (=CNH), 194.34 (C=O). *Anal.* Calcd. for $C_{15}H_{23}NOS$

(265.42): C, 67.88; H, 8.37; N, 5.28; S, 12.08. Found: C, 68.21; H, 9.19; N, 4.96; S, 11.28.

**6-Ethylamino-2-(2,6,6-trimethylcyclohex-2-enyl)-2,3-dihydrothiopyran-4-one (2g).** This compound was obtained in 95% yield as pale yellow crystals; mp 140-143ºC (hexane/benzene); ir: 3412 (NH), 1610 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1265 (NH) $cm^{-1}$; $^1H$ nmr (deuteriochloroform): δ 0.90 (s, 3H, $CH_3$), 1.01 (s, 3H, $CH_3$), 1.11-1.30 (m, 4H, $CH_2CH_3$, $CHHC(CH_3)_2$), 1.53-1.68 (m, 1H, $CHHC(CH_3)_2$), 1.73 (s, 1H, =CCH), 1.85 (s, 3H, $CH_3$), 2.03 (s, 2H, $=CCH_2$), 2.58 (d, 1H, $CHHC=O$, J=8.25 Hz), 2.87 (t, 1H, $CHHC=O$, J=15.54 Hz), 3.15-3.27 (m, 2H, $NCH_2$), 3.85 (d, 1H, SCH, J=14.23 Hz), 4.92 (s, 1H, NH), 5.37 (s, 1H, $=CHCH_2$), 5.52 (s, 1H, =CHC=O). $^{13}C$ nmr (deuteriochloroform): δ 14.09 ($CH_2CH_3$), 23.24 ($=CCH_2$), 26.35 ($CH_3$), 27.06 ($CH_3$), 28.37 ($=CCH_3$), 30.34 ($CH_2C(CH_3)_2$), 33.20 ($C(CH_3)_2$), 39.02 ($NCH_2$), 43.57 (SCH), 47.89 ($CH_2C=O$), 53.52 (=CCH), 95.87 (=CC=O), 124.55($C=CCH_3$), 132.31 ($C=CCH_3$), 164.11 (=CNH), 194.37 (C=O). *Anal.* Calcd. for $C_{16}H_{25}NOS$ (279.45): C, 68.77; H, 9.02; N, 5.01; S, 11.47. Found: C, 68.52; H, 9.38; N, 4.97; S, 11.24.

**6-Cyclohexylamino-2-(2,6,6-trimethylcyclohex-2-enyl)-2,3-dihydrothiopyran-4-one (2h).** This compound was obtained in 94% yield as pale yellow crystals; mp 175-178ºC (heptane/toluene); ir: 3396 (NH), 1604 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1244 (NH) $cm^{-1}$; $^1H$ nmr (deuteriochloroform): δ 0.90 (s, 3H, $CH_3$), 1.01 (s, 3H, $CH_3$), 1.08-1.41 (m, 6H, $CH_2C(CH_3)_2$, $2CH_2$-cyclo), 1.52-1.77 (m, 5H, CH=CC*H*, $2CH_2$-cyclo), 1.85 (s, 3H, $CH_3$), 1.90-2.12 (m, 4H, $=CCH_2$, CH-cyclo), 2.50-2.64 (m, 1H, $CHHC=O$), 2.77-2.92 (m, 1H, $CHHC=O$), 3.35 (s, 1H, NCH), 3.74-3.92 (m, 1H, SCH), 4.69 (s, 1H, NH), 5.42 (s, 1H, $CH=CCH_3$), 5.52 (s, 1H, C=CHC=O). $^{13}C$ nmr (deuteriochloroform): δ 23.27 ($=CCH_2$), 24.63, 25.37 (cyclo), 26.37 ($CH_3$), 27.04 ($CH_3$), 28.39 ($=CCH_3$), 30.33 ($CH_2C(CH_3)_2$), 32.46, 32.91(cyclo), 33.23 ($C(CH_3)_2$), 43.47 (SCH), 47.82 ($CH_2C=O$), 53.03 (cyclo), 53.54 (=CCH), 95.94 (=CC=O), 124.54 ($C=CCH_3$), 132.40 ($C=CCH_3$), 163.07 (=CNH), 194.20 (C=O). *Anal.* Calcd. for $C_{20}H_{31}NOS$ (333.54): C, 72.02; H, 9.37; N, 4.20; S, 9.61. Found: C, 71.44; H, 9.50; N, 4.21; S, 9.04.

**6-Phenylamino-2-(2,6,6-trimethylcyclohex-1-enyl)-2,3-dihydrothiopyran-4-one (2i).** This compound was obtained in 94% yield as pale yellow crystals, mp 148-151ºC (toluene); ir: 3400 (NH), 1608 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1252 (NH) $cm^{-1}$. $^1H$ nmr (deuteriochloroform): δ 0.84 (s, 3H, $CH_3$), 0.95 (s, 3H, $CH_3$), 1.12-1.17 (m, 1H, $CCHHCH_2$), 1.56 (dd, 1H, $CCHHCH_2$, J=22.44, 9.32 Hz), 1.69 (s, 1H, CCHC), 1.81 (s, 3H, $CH_3$), 1.97 (s, 2H, $=CCH_2$), 2.53 (t, 1H, $COCHH$, J=15.75 Hz), 2.87 (t, 1H, COCH*H*, J=15.55 Hz), 3.80 (d, 1H, SCH, J=14.12 Hz), 5.48 (s, 1H, $C=CHCH_2$), 5.72 (s, 1H, C=CHCO), 7.05-7.10 (m, 3H, Ph), 7.11-7.27 (m, 2H, Ph). $^{13}C$ nmr (deuteriochloroform): δ 22.27 ($=CCH_2$), 26.37 ($CH_3$), 27.08 ($CH_3$), 28.41 ($CH_3$), 30.38 ($=CCH_2CH_2$), 33.27 ($CH_2C$), 43.53 (SCH), 47.89 ($CH_2CO$), 53.46 (=CCH), 99.62 (CCHCO), 123.34, 125.51, 129.45, 138.30 (Ph), 124.76 ($=CCH_2$), 132.29 ($C=CCH_2$), 162.35 (SC=CH), 195.33 (C=O). *Anal.* Calcd. for $C_{20}H_{25}NOS$ (327.48): C, 73.35; H, 7.69; N, 4.28; S, 9.79. Found: C, 73.24; H, 7.88; N, 3.98; S, 9.00.

**6-Methylamino-2-(2,6,6-trimethylcyclohex-1-enyl)-2,3-dihydrothiopyran-4-one (2j).** This compound was obtained in 90% yield as pale yellow crystals; mp 202-205ºC (heptane/toluene); ir: 3428 (NH), 1608 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1240 (NH) $cm^{-1}$; $^1H$ nmr (deuteriochloroform): δ 0.99 (s, 3H, $CH_3$), 1.05 (s, 3H, $CH_3$), 1.44 (d, 2H, $CH_2C(CH_3)_2$, J=5.92 Hz), 1.54 (d, 2H, $=CCH_2CH_2$, J=5.04 Hz), 1.92 (s, 3H, $CH_3$), 1.93-2.04 (m, 2H, $=CCH_2CH_2$), 2.46 (d, 1H, $CHHC=O$, J=17.11 Hz), 2.89 (s, 3H, $NHCH_3$), 3.15 (d, 1H, $CHHC=O$, J=17.21 Hz), 4.31 (d, 1H, SCH, J=14.29 Hz), 5.39 (s, 1H, =CHC=O). $^{13}C$ nmr (deuteriochloroform): δ 18.99 ($=CCH_2CH_2$), 22.64 ($=CCH_3$), 27.75 ($CH_3$), 28.12 ($CH_3$), 30.79 ($NCH_3$), 34.49 ($=CCH_2$), 35.90 ($C(CH_3)_2$), 39.53 ($CH_2C(CH_3)_2$), 41.22 (SCH), 42.68 ($CH_2C=O$), 95.07 (=CHC=O), 133.49 ($C=CCH_3$), 136.02 ($C=CCH_3$), 166.49 (=CNH), 194.59 (C=O). *Anal.* Calcd. for $C_{15}H_{23}NOS$ (265.42): C, 67.88; H, 8.37; N, 5.28; S, 12.08. Found: C, 67.83; H, 8.44; N, 5.25; S, 11.52.

**6-Ethylamino-2-(2,6,6-trimethylcyclohex-1-enyl)-2,3-dihydrothiopyran-4-one (2k).** This compound was obtained in 86% yield as pale yellow crystals; mp 185-188ºC (heptane/toluene); ir: 3412 (NH), 1602 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1238 (NH) $cm^{-1}$; $^1H$ nmr (deuteriochloroform): δ 0.99 (s, 3H, $CH_3$), 1.05 (s, 3H, $CH_3$), 1.25 (t, 3H, $CH_2CH_3$, J=7.22 Hz), 1.39-1.50 (m, 2H, $CH_2C(CH_3)_2$), 1.51-1.62 (m, 2H, $=CCH_2CH_2$), 1.92 (s, 3H, $=CCH_3$), 1.93-2.04 (m, 2H, $=CCH_2$), 2.45 (dd, 1H, $CHHC=O$, J=17.11, 2.86 Hz), 3.08-3.33 (m, 3H, $CHHC=O$, $NCH_2$), 4.30 (dd, 1H, SCH, J=14.49, 2.20 Hz), 5.39 (s, 1H, =CHC=O), 5.69 (s, 1H, NH). $^{13}C$ nmr (deuteriochloroform): δ 14.12 ($CH_2CH_3$), 18.97 ($=CCH_2CH_3$), 22.61 ($=CCH_3$), 27.72 ($CH_3$). 28.11 ($CH_3$), 34.47 ($=CCH_2$), 35.86 ($C(CH_3)_2$), 38.95 ($NCH_2$), 39.53 ($CH_2C(CH_3)_2$), 41.06 (SCH), 42.72 ($CH_2C=O$), 94.94 (=CHC=O), 133.54 ($C=CCH_3$), 135.85 ($C=CCH_3$), 165.65 (=CNH), 194.56 (C=O). *Anal.* Calcd. for $C_{16}H_{25}NOS$ (279.45): C, 68.77; H, 9.02; N, 5.01; S, 11.47. Found: C, 68.52; H, 9.38; N, 4.97; S, 11.24.

**6-Cyclohexylamino-2-(2,6,6-trimethylcyclohex-1-enyl)-2,3-dihydrothiopyran-4-one (2m).** This compound was obtained in 84% yield as pale yellow crystals; mp 136-139ºC (heptane/toluene); ir: 3396 (NH), 1604 (C=O, C=C), 1550-1500 (NH, C-N, C=C), 1246 (NH) $cm^{-1}$; $^1H$ nmr (deuteriochloroform): δ 0.93 (s, 3H, $CH_3$), 0.99 (s, 3H, $CH_3$), 1.05-1.32 (m, 4H, $2CH_2$-cyclo), 1.34-1.43 (m, 2H, $CH_2C(CH_3)_2$), 1.48 (t, 2H, $=CCH_2CH_2$, J=5.58 Hz), 1.52-1.73 (m, 4H, $2CH_2$-cyclo), 1.85 (s, 3H, $=CCH_3$), 1.87-2.00 (m, 4H, $=CCH_2$, $CH_2$-cyclo), 2.38 (d, 1H, $CHHC=O$, J=16.97 Hz), 3.07 (d, 1H, $CHHC=O$, J=16.36 Hz), 3.25-3.39 (m, 1H, CH-cyclo), 4.22 (d, 1H, SCH, J=13.89 Hz), 4.84 (s, 1H, NH), 5.34 (s, 1H, =CHC=O). $^{13}C$ nmr (deuteriochloroform): δ 18.99 ($=CCH_2CH_2$), 22.67 ($=CCH_3$), 24.69, 25.37 ($CH_2$-cyclo), 27.73 ($CH_3$), 28.16 ($CH_3$), 32.65 ($CH_2$-cyclo), 34.49 ($=CCH_2$), 35.92 ($C(CH_3)_2$), 39.54 ($CH_2C(CH_3)_2$), 41.12 (SCH), 42.67 ($CH_2C=O$), 53.03 (CH-cyclo), 95.36 (=CHC=O), 133.48 ($C=CCH_3$), 136.04 ($C=CCH_3$), 164.44 (=C-NH), 194.75 (C=O). *Anal.* Calcd. for $C_{20}H_{31}NOS$ (333.54): C, 72.02; H, 9.37; N, 4.20; S, 9.61. Found: C, 71.33; H, 9.52; N, 3.93; S, 9.37.

**General Procedure for Preparation of Thiazolidin-4-ones (4a-d).** Anhydrous potassium carbonate (3.45 g, 25 mmol) and ethyl bromoacetate (1.84g, 11 mmol) were added to the solution of thioamide (**1a**, **e**, **i**, **3**, 10 mmol) in dry THF or acetone (30 mL). The mixture was stirred for 2 h at room temperature and then left overnight. The progress of the reaction was monitored by TLC (silufol/hexane:ethyl acetate 1:1). Upon filtering of the solid parts the solvent was romoved under reduced pressure and the solid residue was dissolved in ethyl acetate and passed through a 10-cm column packed with neutral aluminum oxide, activity II. Evaporation of ethyl acetate left the crude product, which was purified by recrystallization from an appropriate solvent.

**2-(2-Oxo-4-phenylbut-3-enylidene)-3-phenylthiazolin-4-one (4a).** This compound was obtained in 84% yield as pale

orange crystals; mp 247-252ºC (ethanol); ir: 1728 (C=O), 1632 (C=O), 1598 (C=C), 1512 (C=C) $cm^{-1}$; $^1H$ nmr (deuteriochloroform): δ 3.79 (s, 2H, $CH_2C$=O), 5.71 (s, 1H, CH=C-S), 6.35 (d, 1H, PhCH=C*H*, J=15.88 Hz), 7.15-7.27 (m, 4H, Ph), 7.28-7.56 (m, 7H, Ph, PhC*H*=CH). $^{13}C$ nmr (deuteriochloroform): δ 32.22 (*C*$H_2$C=O), 101.59 (*C*H=C-S), 126.61 (PhCH=*C*H), 121.43, 127.98, 129.04, 129.93, 130.31, 135.05 (Ph), 141.48 (Ph*C*H=CH), 161.36 ($CH_2$*C*=O), 172.57 (=C-S), 187.10 (C=O); ms: m/z 321 ($M^+$, 37%), 293 (13%), 244 (29%), 218 (13%), 190 (27%), 131 (27%), 103 (62%), 77 (100%), 51 (28%). *Anal*. Calcd. for $C_{19}H_{15}NO_2S$ (321.39): C, 71.01; H, 4.70; N, 4.36; S, 9.98. Found: C, 70.70; H, 4.95; N, 4.41; S, 10.23.

**2-[2-Oxo-4-(2,6,6-trimethylcyclohex-2-enyl)-but-3-enylidene]-3-phenylthiazolidin-4-one (4b).** This compound was obtained in 82% yield as orange crystals; mp 160-163° (heptane/ ethyl acetate); ir: 1728 and 1644 (C=O), 1608 (C=C), 1512 (C=C) $cm^{-1}$; $^1H$ nmr (deuteriochloroform): δ 0.79 (s, 3H, $CH_3$), 0.87 (s, 3H, $CH_3$) 1.09-1.22 (m, 1H, C*H*HC$(CH_3)_2$), 1.37-1.48 (m, 1H, CH*H*C$(CH_3)_2$), 1.50 (s, 3H, $CH_3$), 1.99 (s, 2H, =C$CH_2$), 2.20 (d, 1H, C*H*CH=CH, J=9.60 Hz), 3.84 (s, 2H, $CH_2$C=O), 5.44 (s, 1H, =C*H*$CH_2$), 5.66 (s, 1H, CH=C-S), 5.97 (d, 1H, CH=C*H*C=O, J=15.31 Hz), 6.66 (dd, 1H, C*H*=CHC=O, J=14.96, 9.83 Hz), 7.25 (d, 2H, Ph, J=7.18 Hz), 7.48-7.76 (m, 3H, Ph). $^{13}C$ nmr (deuteriochloroform): δ 22.87 ($CH_3$), 23.00 (=CH*C*$H_2$), 26.90 ($CH_3$), 27.65 ($CH_3$), 31.18 (*C*$H_2$C$(CH_3)_2$), 32.14 (*C*$H_2$C=O), 32.61 (*C*$(CH_3)_2$), 54.07 (*C*HCH=CH), 101.12 (*C*H=C-S), 122.34, 127.96, 130.21, 135.06 (Ph), 129.82 (=*C*H$CH_2$), 130.88 (CH=*C*HC=O), 132.08 (*C*=C$HCH_2$), 147.03 (*C*H=CHC=O), 160.99 ($CH_2$C=O), 172.53 (=C-S), 187.10 (=CHC=O). MS: m/z 367 ($M^+$, 56%), 311 (43%), 218 (81%), 190 (68%), 162 (21%), 144 (37%), 117 (25%), 77 (100%), 44 (28%). *Anal*. Calcd. for $C_{22}H_{25}NO_2S$ (367.51): C, 71.90; H, 6.86; N, 3.81; S, 8.72. Found: C, 71.86; H, 7.17; N, 3.80; S, 8.50.

**2-[2-Oxo-4-(2,6,6-trimethylcyclohex-1-enyl)-but-3-enylidene]-3-phenylthiazolidin-4-one (4c).** This compound was obtained in 80% yield as pale orange crystals; mp 161-165ºC (*n*-hexane/ethyl acetate); ir: 1724 and 1662 (C=O), 1596 and 1514 (C=C); $^1H$ nmr (deuteriochloroform): δ 1.01 (s, 6H, $2CH_3$), 1.44 (s, 2H, C*H*$_2$C$(CH_3)_2$), 1.58 (s, 2H, =C$CH_2$C*H*$_2$), 1.85 (s, 3H, =C$CH_3$), 2.02 (s, 2H, =C$CH_2$), 3.87 (s, 2H, $CH_2$C=O), 5.68 (s, 1H, CH=C-S), 6.02 (d, 1H, =C-CH=C*H*, J=15.87 Hz), 7.14-7.26 (m, 2H, Ph), 7.33 (d, 1H, =C-C*H*=CH, J=16.19 Hz), 7.46-7.66 (m, 3H, Ph); $^{13}C$ nmr (deuteriochloroform): δ 18.90 (=C$CH_2$*C*H$_2$), 21.82 (=C*C*$H_3$), 28.79 ($CH_3$), 32.21 (*C*$H_2$C=O), 33.66 (=C*C*$H_2$), 34.12 (*C*$(CH_3)_2$), 39.80 (*C*$H_2$C$(CH_3)_2$), 101.68 (CH=C-S), 127.98, 130.22, 130.31, 135.06 (Ph), 129.81 (=CCH=*C*H), 136.11 (=*C*C$H_3$), 136.36 (=*C*CH=CH), 141.42 (=C*C*H=CH), 160.51 ($CH_2$*C*=O), 172.56 (=C-S), 187.52 (C=O). MS: m/z 367 ($M^+$, 22%), 352 (76%), 276 (100%), 218 (56%), 190 (58%), 133 (54%), 91 (38%), 77 (78%), 41 (22%). *Anal*. Calcd. for $C_{22}H_{25}NO_2S$ (367.51): C, 71.90; H, 6.86; N, 3.81; S, 8.72. Found: C, 71.49; H, 6.75; N, 3.65; S, 8.70.

**2-(6,10-dimethyl-2-oxoundeca-3,5,9-trienylidene)-3-phenylthiazolidin-4-one (4d).** This compound was obtained in 40% yield as pale yellow crystals; mp 160-162ºC (*n*-hexane/ ethyl acetate); ir: 3033 (=CH), 2860 ($SCH_2$), 1726 and 1648 (C=O) $cm^{-1}$; $^1H$ nmr (deuteriochloroform): δ 1.55 (s, 3H, $CH_3$), 1.63 (s, 3H, $CH_3$), 1.84 (s, 3H, $CH_3$), 1.96-2.21 (m, 4H, $2CH_2$), 3.83 (s, 2H, $SCH_2$), 5.02 (s, 1H, $(CH_3)_2$C=C*H*), 5.64 (s, 1H, $CH_3$C=C*H*), 5.81-6.06 (m, 2H, CH=C-S, CH-C=O), 7.15-7.34 (m, 2H, Ph), 7.38-7.64 (m, 3H, Ph, C*H*=CHC=O). $^{13}C$ nmr (deuteriochloroform): δ 16.67 ($CH_3$), 16.71 ($CH_3$), 24.65 ($CH_3$), 25.26 (($CH_3)_2$C=CH*C*$H_2$), 31,17 ($CH_2$C=O), 39.40 (*C*$H_2$C$CH_3$), 100.83 (*C*H=C-S), 122.29, 122.33, 128.74, 131.14 (Ph), 122. 78 ($CH_3$C=*C*H), 126.89 (($CH_3)_2$C=C*H*), 129.14 (=*C*HC=O), 134.10 (($CH_3)_2$*C*), 137.10 (*C*H=CHC=O), 149.79 ($CH_3$*C*), 159.32 (NC=O), 171.51 (=C-S), 186.75 (C=O); ms: m/z 367 ($M^+$, 8%), 284 (53%), 218 (83%), 190 (61%), 77 (76%), 69 (82%), 41 (100%). *Anal*. Calcd. for $C_{22}H_{25}NO_2S$ (367.50): C, 71.83; H, 6.80; N, 3.81; S, 8.70. Found: C, 71.05; H, 6.74; N, 3.72; S, 8.52

**Preparation of 4-oxo-6-phenyl-2-phenylamino-5,6-dihydro-4*H*-thiopyran-3-carbothioic acid phenylamide (6).** 2-Phenyl-6-phenylamino-2,3-dihydrothiopyran-4-one (**2a**, 0.66 g, 2.35 mmol) was dissolved in 25 mL of warm toluene and sodium hydride (10 mmol, 80% suspension in mineral oil) was added under cooling. The mixture was refluxed for 25 min, cooled, and treated with a solution of phenyl isothiocyanate (0.635 g, 0.56 mL, 4.7 mmol) in 2 mL of toluene. Refluxing was continued for 5 h to complete the reaction. Upon cooling, the mixture was washed with a slightly acidified (hydrochloric acid) cold saturated solution of sodium chloride. The toluene layer was separated while the aqueous layer was extracted with ethyl acetate; the combined organic solutions were washed with a saturated sodium chloride solution and dried. A routine work-up left the crude product, which was purified by column chromatography (silica gel) with a 2:1 mixture of *n*-hexane/ethyl acetate as the eluent.

This compound was obtained in 75% yield as pale yellow crystals; mp 193-197ºC (methanol/trace of methylene chloride); $^1H$ nmr (deuteriochloroform): δ 3.02 (d, 1H, C*H*HC=O, J=15.54 Hz), 3.34 (d, 1H, CH*H*C=O, J=14.84 Hz), 4.45 (d, 1H, SCH, J=15.53 Hz), 7.01-7.18 (m, 8H, Ph), 7.19-7.32 (m, 3H, Ph), 7.33-7.50 (m, 4H, Ph), 14.47 (s, 1H, NH), 15.91 (s, 1H, NH). $^{13}C$ nmr (deuteriochloroform): δ 42.28 (SCH), 46.84 ($CH_2$C=O), 105.31 (=*C*C=S), 126.42, 125.50, 126.73, 127.67, 128.39, 128.82, 128.97, 129.20, 129.45, 136.46, 136.95, 139.21 (3Ph), 174.45 (C=S), 189.12 (=CNH), 192.85 (C=O). *Anal*. Calcd. for $C_{24}H_{20}N_2OS_2$ (416.51): C, 69.20; H, 4.84; N, 6.72; S, 15.39. Found: C, 69.03; H, 4.83; N, 6.69; S, 15.26.

**Preparation of 2,5,8-Triphenyl-2,3,5,8- and 2,5,8-triphenyl-2,3,7,8-tetrahydrothiopyrano[2,3-*b*]pyridin-4-ones (7a-b).** A solution of 3,4-dihydrothiopyran-4-one **2a** (1 mmol), cinnamaldehyde (1.5 mmol) and triethylamine (25 mmol, 0.35 mL) in ethanol (50 mL) was refluxed until the thioamide substrate disappeared (about 5 h). The reaction progress was monitored by TLC (silufol/ hexane-ethyl acetate 2:2). Upon evaporation of the solvent under reduced pressure, the crude product was chromatographed on silica gel using *n*-hexane-ethyl acetate (3:2) as the eluent and finally purified by recrystallization from cyclohexane/methanol.

The product was identified by nmr as a 3:2 mixture of **7a** and **7b** isolated in the form of pale yellow crystals, mp 130-132ºC, ir: 3060 (Ph),1610 (C=O).

**2,5,8-Triphenyl-2,3,5,8-tetrahydrothiopyrano[2,3-*b*]-pyridin-4-one (7a).** $^1H$ nmr (deuteriochloroform): δ 2.85 (d, 1H, C*H*HC=O, J=15.80 Hz), 3.12 (d, 1H, CH*H*C=O, J=14.77 Hz), 4.53 (d, 1H, SCH, J=13.77 Hz), 5.26 (s, 1H, =CHPh), 5.42-5.52 (m, 1H, =C-CH-Ph), 7.03 (d, 1H, NCH=, J=9.78 Hz), 7.10-7.22 (m, 3H, Ph), 7.24-7.44 (m, 12H, Ph); $^{13}C$ nmr (deuteriochloroform): δ 26.93 (=CH-*C*H-Ph), 43.88 (*C*$H_2$C=O), 46.00 (SCH), 106.05 (NCH=*C*H), 119.89 (=*C*-C=O), 127.63, 127.78, 127.93, 128.37, 128.85, 128.91, 129.39, 141.20, 142.25 (Ph), 128.73 (N*C*H=CH), 142.58 (=C-S), 188.42 (C=O).

**2,5,8-Triphenyl-2,3,7,8-tetrahydrothiopyrano[2,3-*b*]pyridin-4-one (7b).** $^1$H nmr (deuteriochloroform): δ 2.93 (d, 1H, C*H*HC=O, J=14.27 Hz), 3.16 (d, 1H, CH*H*C=O, J=14.50 Hz), 4.62 (d, 1H, SCH, J=13.06 Hz), 5.29 (d, 1H, NC*H*H, J=5.02 Hz), 5.45 (d, 1H, NCH*H*, J=4.94 Hz), 6.98 (s, 1H, CH=CPh), 7.10-7.22 (m, 3H, Ph), 7.24-7.44 (m, 12H, Ph); $^{13}$C nmr (deuteriochloroform): δ 43.46 (*C*$H_2$C=O), 46.46 (SCH), 68.24 (NC$H_2$), 115.15 (CH=C-Ph), 119.13 (=*C*-C=O), 127.62, 127.78, 127.93, 128.42, 128.85, 129.17, 129.38, 142.25 (Ph), 137.69 (=C-Ph), 160.41 (=C-S), 188.11 (C=O). *Anal.* Calcd. for $C_{26}H_{21}NOS$ (395.52): C, 78.96; H, 5.35; N, 3.54; S, 8.11. Found: C, 78.75; H, 5.50; N, 3.21; S, 8.01.

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