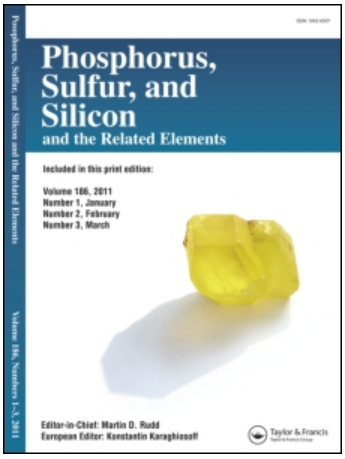

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REACTIONS OF ACYLFORMYLKETENE S,S-AND S,N-ACETALS WITH AMINES

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REACTIONS OF ACYLFORMYLKETENE S,S- AND S,N-ACETALS WITH AMINES

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Acylformylketene S,S- and S,N-acetals **1** and **12** react with amines substituting one or both donor groups at the acetal carbon atom leading to **2–5**, **7**, **9–11**, **13**, **14** and **18** and also yielding azomethines **6–9**, **11**, **17** and **21**. Obviously, the reaction at the acetal carbon proceeds by thermodynamic control and at the aldehyde carbon by kinetic control. 1,4-Dinucleophiles are appropriate building blocks for heterocycles **19**, **20** and **22**.

Key words: Acylformylketene acetal, azomethine, hexahydropyrimidine, 2,3-dihydrobenzazoles, oxazolidine, imidazolidine, 1,5-benzodiazepine.

INTRODUCTION

Typically, acceptor substituted ketene acetals react with nucleophiles at the acetal carbon atom. Furthermore, they have high stability which results in the tendency for substitution reactions instead of addition reactions, characteristic of most alkenes. Thus, compounds of this type have a regenerative character since the push-pull-system is maintained.[1–3]

Nucleophiles may attack acylformyl acetals by three different routes: at the acetal carbon atom, at the aroyl group, and at the aldehyde group.[4]

We were interested in investigating the differences in reactivity of these three electrophilic centers. In addition, use of 1,4-dinucleophiles should allow access to a variety of heterocycles.

RESULTS AND DISCUSSION

Treatment of 2-benzoyl-3,3-bis(ethylthio)-2-propenal **1a** with an excess of ammonia leads, by substitution of one ethylthio group, to the formation of 3-amino-2-benzoyl-3-ethylthio-2-propenal **2**, exclusively. Variation of ammonia concentration, reaction time and temperature also gave the sample product **2**. In the ^{1}H NMR spectrum of **2** it is possible to distinguish between the amino protons (δ = 6.36 and δ = 12.51 ppm) due to intramolecular hydrogen bond to one of the carbonyl groups.

Reaction of **1a** with an excess of methylamine in refluxing methanol yields 2-benzoyl-3,3-bis(methylamino)-2-propenal **3**. The chelate structure of this compound was proved by ^{1}H NMR and IR spectroscopy.[5] Use of an equimolar amount of methylamine gave the desired product in lower yield. No trace of a monosubstituted compound was detected.

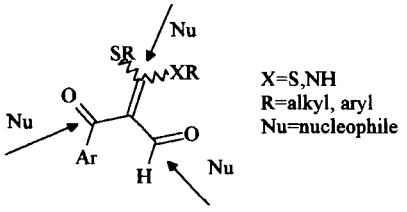
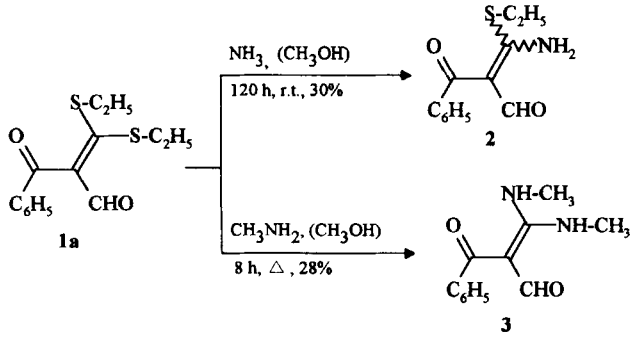
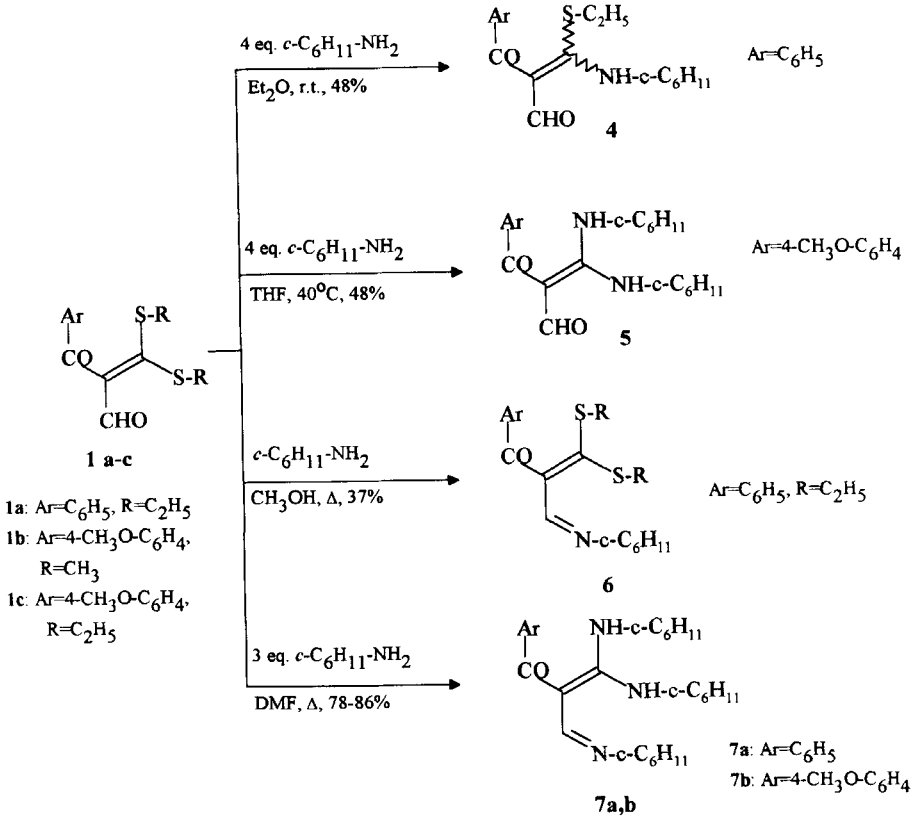


FIGURE 1



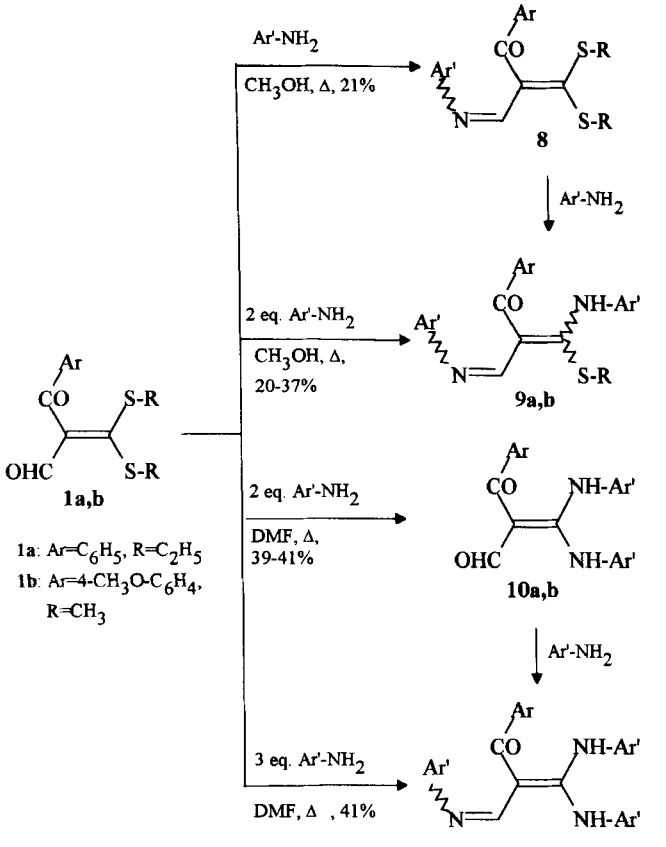
SCHEME 1



SCHEME 2

Reactions of the acylformylketene S,S-acetals **1a–c** with cyclohexylamine yield either ketene S,N-acetal **4**, ketene N,N-acetal **5** or azomethine **6** depending on the solvent used for the reaction. With an excess of cyclohexylamine in refluxing dimethylformamide both alkylthio groups are displaced and reaction also takes place at the aldehyde group to yield products **7a** and **7b**. In the ^{1}H NMR spectra of these compounds the amino protons appear as two doublets at $\delta \sim 11.5$ ppm and $\delta \sim 4.1$ ppm, respectively, with a coupling constant of 7 Hz indicating a fixed geometry,[6,7]

Furthermore, the course of the reaction of **1a,b** with aniline or *p*-fluoroaniline depends upon the amount of the nucleophile present and the solvent used. One



comp.	Ar	R	Ar'
8	C_6H_5	C_2H_5	C_6H_5
9a	C_6H_5	C_2H_5	C_6H_5
9b	4-CH_3O-C_6H_4	CH_3	4-F-C_6H_4
10a	C_6H_5	-	C_6H_5
10b	4-CH_3O-C_6H_4	-	4-F-C_6H_4
11	C_6H_5	-	C_6H_5

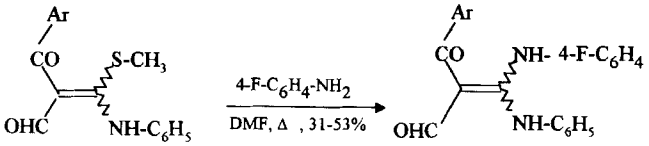
SCHEME 3

equivalent of aniline in methanol or ethanol yields 2-benzoyl-1,1-bis(ethylthio)-3-phenylimino-propene **8**. Only with an excess of aniline in the same solvent one alkylthio group is replaced to yield compounds **9a,b**. In comparison, use of dimethylformamide as solvent during treatment of **1a,b** with 2–3 equivalents of aniline results in substitution of both alkylthio groups to furnish the ketene N,N-acetals **10a,b** in one step. Further heating under reflux of **10a** with one equivalent of aniline leads to 1,1-bis(anilino)-2-benzoyl-3-phenylimino-propene **11**. Compounds **9a,b** and **11** can also be obtained directly from **1a,b** by treatment with the corresponding amount of aniline or *p*-fluoroaniline as shown in Scheme 3.

Treatment of ketene S,N-acetals **12a,b**[4] with *p*-fluoroaniline yields the ketene N,N-acetals **13a,b**. The reaction proceeds by chemoselective displacement of the alkylthio group.

Treatment of **1a** with 2 equivalents of benzylamine yields the corresponding ketene N,N-acetal **14**. The same reaction product was obtained in a very low yield by using only one equivalent of benzylamine. Further refluxing of **14** with an excess of benzylamine leads to 2-benzoyl-1,1-bis(benzylamino)-3-(benzylimino)-propene **15**.

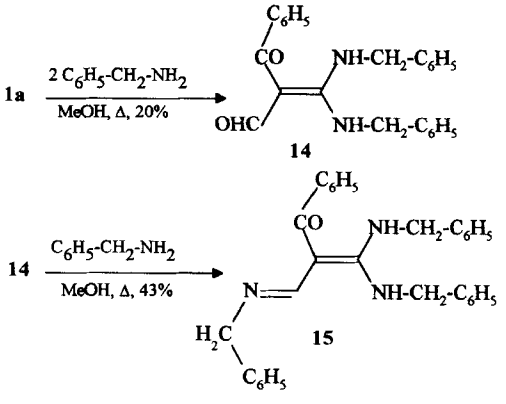
As expected, the nucleophilic attack at the acetal carbon atom of cyclic ketene S,S-acetals **16** is disfavored due to steric hindrance and the stability of the 1,3-dithiolane ring. Thus, reactions of **16a–d** with anilines yield the corresponding azomethines **17a–e**, exclusively.



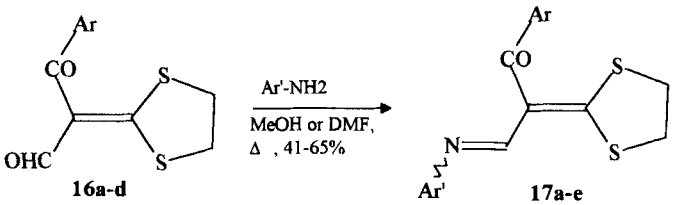
12a,b **13a,b**

12a, 13a: Ar=4-Br-C_6H_4
12b, 13b: Ar=4-CH_3O-C_6H_4

SCHEME 4



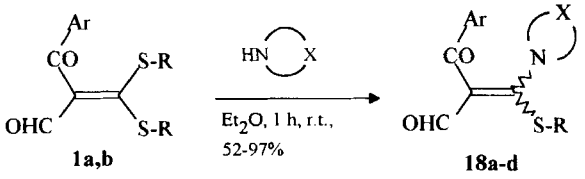
SCHEME 5



16	Ar
a	C_6H_5
b	4-Br-C_6H_4
c	4-Cl-C_6H_4
d	4-F-C_6H_4

17	Ar	Ar'
a	C_6H_5	C_6H_5
b	4-Br-C_6H_4	C_6H_5
c	4-Cl-C_6H_4	C_6H_5
d	C_6H_5	4-F-C_6H_4
e	4-F-C_6H_4	4-F-C_6H_4

SCHEME 6



1a: Ar=C_6H_5; R=C_2H_5
1b: Ar=4-CH_3O-C_6H_4; R=CH_3

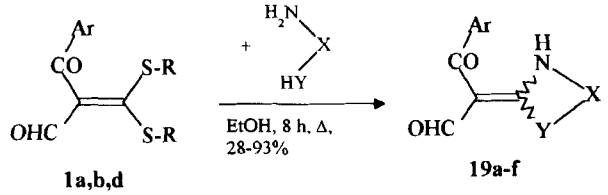
18	Ar	R	X
a	C_6H_5	C_2H_5	$-(CH_2)_2-O-(CH_2)_2-$
b	4-CH_3O-C_6H_4	CH_3	$-(CH_2)_2-O-(CH_2)_2-$
c	4-CH_3O-C_6H_4	CH_3	$-(CH_2)_4-$
d	4-CH_3O-C_6H_4	CH_3	$-(CH_2)_5-$

SCHEME 7

Secondary amines, such as pyrrolidine, morpholine and piperidine, replace only one alkylthio group from the formylketene S,S-acetals **1a,b** to furnish the corresponding ketene S,N-acetals **18a–d**. Reactions proceed cleanly in diethyl ether at room temperature and are high yielding. On the contrary, reactions carried out in DMF or methanol gave mixtures which could not be separated by chromatography.

The experimental results obtained show that the reaction at the acetal carbon proceeds by thermodynamic control and at the aldehyde carbon by kinetic control. In general, the more basic/nucleophilic aliphatic amines are reactive enough to overcome the higher energy barrier towards 'acetal attack,' especially if the reaction is carried on long enough and/or at high enough temperature. If not, then the imine is formed *via* kinetic control (cf. the formation of **6**), possibly reversibly. When the conditions are rigorous (refluxing DMF), even the less reactive aromatic amines attack the acetal carbon (cf. the formation of **10a,b**), otherwise the imines are formed.

Recently, we have shown that acylformylketene acetals are versatile synthons of a large variety of heterocycles.[8,9] These compounds react with 1,2- and 1,3-dinucleophiles to give 5- or 6-membered heterocyclic compounds, respectively. Due to these favorable results we were especially interested in investigating the reaction behavior of ketene S,S- and S,N-acetals towards 1,4- and 1,5-dinucleophiles. The formylketene S,S-acetals **1a,b,d** react with 2-aminoethanol, 1,3-diaminopropane, *o*-phenylenediamine, 2-aminothiophenol and 2-aminophenol by displacement of both alkylthio groups. There was not observed any reaction at the formyl or benzoyl group.

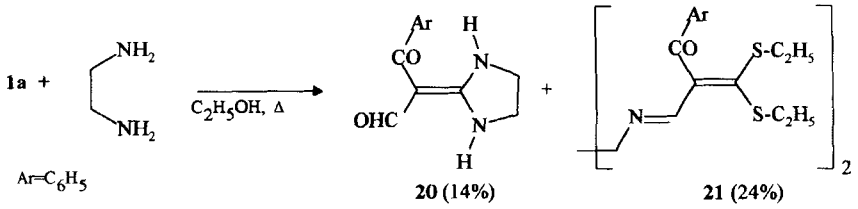


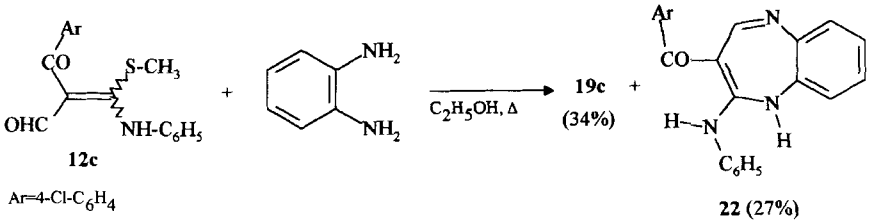
1a,b,d **19a-f**

1a: Ar=C_6H_5, R=C_2H_5
1b: Ar=4-CH_3O-C_6H_4, R=CH_3
1d: Ar=4-Cl-C_6H_4, R=C_2H_5

19	Ar	X	Y
a	C_6H_5	$(CH_2)_2$	O
b	C_6H_5	$(CH_2)_3$	NH
c	4-Cl-C_6H_4		NH
d	4-CH_3O-C_6H_4		NH
e	4-Cl-C_6H_4		O
f	C_6H_5		S

SCHEME 8





SCHEME 9

The ^{1}H NMR spectra of the isolated compounds **19a–f** show the aldehyde protons between δ = 9.20–9.70 ppm. Broad signals between δ = 10.70–12.92 ppm in compounds **19b–d** indicate intramolecular hydrogen bond. In addition, treatment of the ketene S,S-acetal **1a** with 1,2-diaminoethane gives both the imidazolidine **20** and the bis-azomethine **21**. Furthermore, the acylformylketene S,N-acetal **12c**[4] reacts with *o*-phenylenediamine to yield the corresponding benzimidazoline **19c** and the 1,5-benzodiazepine **22**.

EXPERIMENTAL

All melting points are uncorrected. IR spectra were recorded on a Zeiss Specord 71 IR. The ν-values are expressed in cm^{-1}. NMR spectra were recorded on Bruker WP 200 or AC 80 NMR spectrometers with TMS as internal standard. The chemical shifts are expressed in ppm and the coupling constants in Hz. Mass spectra were recorded by using a M. v. Ardenne Mass Spectrometer (16 eV) and an EI-MS (AMD Intectra GmbH; 70 eV). Microanalyses were performed in the Department of Chemistry, Martin Luther University Halle.

Preparation of 3-amino-2-benzoyl-3-ethylthio-2-propenal **2**: 2.8 g (0.01 mol) 2-benzoyl-3,3-bis(ethylthio)-2-propenal **1a** were dissolved in dry methanol (50 ml) and treated with 10 ml of a concentrated ammonia solution. The mixture was stirred at room temperature for 120 h. The precipitate was filtered and recrystallized. By evaporation of the solvent 5.5% of the starting material are obtained. Yield 30%; m.p. 190–200°C (methanol); Found (%) C, 61.03; H, 5.59; N, 5.85; S, 13.83. $C_{12}H_{13}NO_2S$ (235.30) requires C, 61.25; H, 5.57; N, 5.95; S, 13.63; ν = 3330 (NH), 1670 and 1605 (CO); δ_H ($CDCl_3$) = 1.43 (t, 3H, J = 7), 2.84 (q, 2H, J = 7), 6.36 (br.s, 1H), 7.38–7.51 (m, 5H), 9.41 (s, 1H), 12.51 (br.s, 1H); m/z (%) = 235(62) [M$^+$], 105(100).

Preparation of 2-benzoyl-3,3-bis(methylamino)-2-propenal **3**: 2.8 g (0.01 mol) 2-benzoyl-3,3-bis(ethylthio)-2-propenal **1a** was dissolved in a mixture of 5 ml of a 33% solution (0.05 mol) of methylamine and 60 ml methanol. The solution was refluxed for 8 h. After cooling the solvent was evaporated under reduced pressure to yield a yellow oil which was crystallized by treatment with diethyl ether. Yield 28%; m.p. 102–103°C (diethyl ether); Found (%) C, 66.09; H, 6.36; N, 12.78. $C_{12}H_{14}N_2O_2$ (218.26) requires C, 66.04; H, 6.47; N, 12.84; ν = 2930 (NH), 1636 and 1605 (CO); δ_H ($CDCl_3$) = 3.18 (d, 6H, J = 5), 7.37 (m, 5H), 9.19 (s, 1H), 11.06 (br.s, 2H); m/z (%) = 218(34) [M$^+$], 105(100).

Preparation of 2-benzoyl-3-cyclohexylamino-3-ethylthio-2-propenal **4**: 1.98 g (0.02) mol) cyclohexylamine was added to a solution of 2.8 g (0.01 mol) 2-benzoyl-3,3-bis(ethylthio)-2-propenal **1a** in diethyl ether (80 ml). The mixture was stirred at room temperature for 1 h before removal of the solvent by evaporation under reduced pressure. The crude oil was treated with *n*-pentane to give the solid product. Yield 48%; m.p. 70–71°C (*n*-pentane); Found (%) C, 67.80; H, 7.41; N, 4.25; S, 10.28. $C_{18}H_{23}NO_2S$ (317.45) requires C, 68.11; H, 7.30; N, 4.41; S, 10.10; ν = 1680 and 1600 (CO); δ_H ($CDCl_3$) = 0.86–3.29 (m, 16H), 3.94 (br.s, 1H), 7.40–7.80 (m, 5H), 9.23 (s, 1H); m/z (%) = 317(3) [M$^+$], 105(100).

Preparation of 3,3-bis(cyclohexylamino)-2-(4-methoxybenzoyl)-2-propenal **5**: 3.1 g (0.01 mol) 3,3-bis(ethylthio)-2-(4-methoxybenzoyl)-2-propenal **1c** and 3.97 g (0.04 mol) cyclohexylamine were dissolved in dry THF (40 ml) and stirred at 40°C for 2 h. The solvent was evaporated under reduced pressure and the crude oil obtained was treated with petroleum ether to give the solid product. Yield 48%; m.p. 76–78°C (diethyl ether); Found (%) C, 71.76; H, 8.43; N, 7.54. $C_{23}H_{32}N_2O_3$ (384.52) requires C, 71.84; H, 8.39; N, 7.29; ν = 1640 and 1625 (CO); δ_H ($CDCl_3$) = 0.93–2.04 (m, 20H), 2.53–2.66 (m, 2H), 3.44 (d, 1H, J = 7), 6.84 (dd, 2H, J = 9 and 2), 7.40 (dd, 2H, J = 9 and 2), 8.24 (s, 1H), 11.16 (d, 1H, J = 7); m/z (%) = 384(100) [M$^+$].

Preparation of 2-benzoyl-3-cyclohexylimino-1,1-bis(ethylthio)-propene **6**: 5.6 g (0.02 mol) of 2-benzoyl-3,3-bis(ethylthio)-2-propenal **1a** and 1.98 g (0.02 mol) cyclohexylamine were dissolved in methanol (50 ml) and heated under reflux for 0.75 h. The solution was allowed to reach room temperature, and the solvent was removed *in vacuo* to yield a yellow oil which gave the solid product after treatment with diethyl ether. Yield 37%; m.p. 79.5–83°C (methanol); Found (%) C, 66.47; H, 7.38; N, 3.58; S, 17.83. $C_{20}H_{27}NOS_2$ (361.56) required C, 66.44; H, 7.53; N, 3.87; S, 17.73; ν = 1670 (CO); δ_H ($CDCl_3$) = 1.01 (t, 3H, J = 7), 1.32 (t, 3H, J = 7), 0.62–3.38 (m, 15H), 7.38–7.83 (m, 5H), 8.69 (s, 1H); m/z (%) = 361(24) [M$^+$], 105(100).

Preparation of 2-aroyl-1,1-bis(cyclohexylamino)-3-(cyclohexylimino)-propenes **7a,b**: *General Procedure:* 2.98 g (0.03 mol) cyclohexylamine was added to a solution of 0.01 mol of the corresponding acylformylketene S,S-acetal **1a,b** in dry DMF (25 ml). The mixture was refluxed for 8 h. After cooling, the solution was poured onto ice/water (200 ml). The precipitate was filtered, dried and recrystallized.

2-Benzoyl-1,1-bis(cyclohexylamino)-3-(cyclohexylimino)-propene **7a**: Yield 78%; m.p. 216–217°C (methanol); Found (%) C, 77.23; H, 9.36; N, 9.41. $C_{28}H_{41}N_3O$ (435.65) requires C, 77.20; H, 9.49; N, 9.65; ν = 1605 (CO); δ_H ($CDCl_3$) = 1.19–2.07 (m, 30H), 3.28 (d, 3H, J = 14), 4.17 (d, 1H, J = 7), 5.20 (s, 1H), 7.32–7.81 (m, 5H), 11.51 (d, 1H, J = 7); m/z (%) = 434(1) [$M^+ - 1$], 326(100).

1,1-Bis(cyclohexylamino)-3-(cyclohexylimino)-2-(4-methoxybenzoyl)-propene **7b**: Yield 86%; m.p. 163–166°C (methanol); Found (%) C, 74.63; H, 9.55; N, 9.15. $C_{29}H_{43}N_3O_2$ (465.68) requires C, 74.80; H, 9.31; N, 9.02; ν = 1605 (CO); δ_H ($CDCl_3$) = 1.14–2.07 (m, 30H), 3.28 (d, 3H, J = 14), 3.81 (s, 3H), 4.09 (d, 1H, J = 7), 5.16 (s, 1H), 6.85 (dd, 2H, J = 9 and 2), 7.77 (dd, 2H, J = 9 and 2), 11.46 (d, 1H, J = 7); m/z (%) = 465(2) [M^+], 135(100).

Preparation of 2-benzoyl-1,1-bis(ethylthio)-3-phenylimino-propene **8**: 5.6 g (0.02 mol) 2-benzoyl-3,3-bis(ethylthio)-2-propenal **1a** and 1.86 g (0.02 mol) aniline were refluxed in dry methanol (60 ml) for 2 h. The orange oil obtained after removal of the solvent was stirred with a small amount of *n*-heptane at room temperature to give the solid product. Yield 21%; m.p. 82–84°C (methanol); Found (%) C, 67.34; H, 5.79; N, 3.67; S, 18.10. $C_{20}H_{21}NOS_2$ (355.51) requires C, 67.57; H, 5.95; N, 3.94; S, 18.04; ν = 1660 (CO); δ_H ($CDCl_3$) = 1.06 (t, 3H, J = 7), 1.34 (t, 3H, J = 7), 2.77 (q, 2H, J = 7), 2.92 (q, 2H, J = 7), 7.01–7.94 (m, 10H), 8.92 (s, 1H); m/z (%) = 355(12) [M^+], 105(100).

Preparation of the 1-alkylthio-1-anilino-2-aroyl-3-phenylimino-propenes **9a,b**: *General Procedure:* A mixture of 0.01 mol of the corresponding acylformylketene S,S-acetal and 1.86 g (0.02 mol) aniline or 2.22 g (0.02 mol) 4-fluoroaniline in dry ethanol (30 ml) was refluxed for 5 h. The solution was then allowed to reach room temperature, and the solvent was removed by evaporation under reduced pressure. A small amount of acetone was added to the crude oil to yield the crystalline product.

1-Anilino-2-benzoyl-1-ethylthio-3-phenylimino-propene **9a**: Yield 20%; m.p. 112–115°C (acetone); Found (%) C, 74.34; H, 5.72; N, 7.05; S, 8.52. $C_{24}H_{22}N_2OS$ (386.51) requires C, 74.58; H, 5.74; N, 7.25; S, 8.29; ν = 1630 (CO); δ_H ($CDCl_3$) = 1.38 (m, 3H), 3.06 (m, 2H), 6.23–7.45 (m, 15H), 7.95 and 8.12 (s, 1H, E- and Z-diastereoisomers of CH=N), 11.95 (br.s, 1H); m/z (%) = 386(12) [M^+], 105(100).

1-Ethylthio-1-(4-fluoroanilino)-3-(4-fluorophenylimino)-2-(4-methoxybenzoyl)-propene **9b**: Yield 37%; m.p. 113–116°C (diethyl ether); Found (%) C, 65.81; H, 4.86; N, 6.10; S, 7.27. $C_{24}H_{20}F_2N_2O_2S$ (438.49) requires C, 65.74; H, 4.60; N, 6.39; S, 7.31; ν = 1610 (CO); m/z (%) = 438(7) [M^+], 135(100).

Preparation of 3,3-bis(anilino)-2-aroyl-2-propenals **10a,b**: *General Procedure:* 0.01 mol of the corresponding acylformylketene S,S-acetal were dissolved in dry DMF (30 ml). 0.93 g (0.01 mol) aniline or 1.11 g (0.01 mol) 4-fluoroaniline was then added. The mixture was heated under reflux for about 6 h. After cooling, the solution was poured onto ice/water (50 ml) and extracted with chloroform (3 × 30 ml). The combined organic layers were dried over magnesium sulfate and the solvent was removed *in vacuo* to yield an oil, which crystallized after trituration with methanol.

3,3-Bis(anilino)-2-benzoyl-2-propenal **10a**: Yield 41%; m.p. 167.5–168.5°C (methanol); Found (%) C, 77.03; H, 5.28; N, 7.94. $C_{22}H_{18}N_2O_2$ (342.40) requires C, 77.17; H, 5.30; N, 8.18; ν = 1650 and 1630 (CO); δ_H ($CDCl_3$) = 6.93–8.46 (m, 15H), 11.76 (s, 1H), 12.65 (br.s, 1H), 12.80 (br.s, 1H); m/z (%) = 342(35) [M^+], 105(100).

3,3-Bis(4-fluoroanilino)-2-(4-methoxybenzoyl)-2-propenal **10b**: Yield 39%; m.p. 199–200°C (ethanol); Found (%) C, 67.75; H, 4.44; N, 6.69. $C_{23}H_{18}F_2N_2O_3$ (408.40) requires C, 67.64; H, 4.44; N, 6.86; ν = 3120 (NH), 1645 and 1630 (CO); δ_H ($CDCl_3$) = 3.88 (s, 3H), 6.91–8.06 (m, 12H), 11.70 (s, 1H), 12.53 (br.s, 1H), 12.59 (br.s, 1H); m/z (%) = 408(65) [M^+], 298(100).

Preparation of 1,1-bis(anilino)-2-benzoyl-3-phenylimino-propene **11**: 2.79 g (0.03 mol) aniline was added to a solution of 2.8 g (0.01 mol) 2-benzoyl-3,3-bis(ethylthio)-2-propenal **1a** in dry DMF (30 ml) and the mixture was refluxed for 8 h before pouring onto ice/water (50 ml) and extraction with chloroform (3 × 30 ml). The organic layers were combined, dried over magnesium sulfate and the solvent removed by evaporation to yield an oil. This was triturated with methanol to give the crystalline product. Yield 41%; m.p. 155–157°C (methanol); Found (%) C, 80.35; H, 5.58; N, 9.94. $C_{28}H_{23}N_3O$ (417.51)

requires C, 80.55; H, 5.55; N, 10.06; ν = 1630 (CO); δ_H ($CDCl_3$) = 6.70–7.52 (m, 20H), 8.74 (s, 1H), 11.98 (br.s, 2H).

Preparation of the 3-anilino-2-aroyl-3-(4-fluoroanilino)-2-propenals **13a,b**: *General Procedure*: 0.01 mol of the corresponding acylformylketene S,N-acetal **12a,b** and 1.67 g (0.015 mol) 4-fluoroaniline were refluxed in dry DMF for 2 h. After cooling, the mixture was poured onto ice/water (200 ml) and the precipitate was filtered and recrystallized.

3-Anilino-2-(4-bromobenzoyl)-3-(4-fluoroanilino)-2-propenal **13a**: Yield 53%; m.p. 192–195°C (ethanol); Found (%) C, 60.21; H, 3.59; N, 6.35; Br, 18.31. $C_{22}H_{16}BrFN_2O_2$ (439.28) requires C, 60.15; H, 3.67; N, 6.38; Br, 18.19; ν = 1660 and 1625 (CO); δ_H ($CDCl_3$) = 6.91–8.07 (m, 13 H), 11.62 (s, 1H), 12.74 (br.s, 2H); m/z (%) = 438, 440(12) [M^+], 183(100).

3-Anilino-3-(4-fluoroanilino)-2-(4-methoxybenzoyl)-2-propenal **13b**: Yield 31%; m.p. 160–162°C (methanol); Found (%) C, 70.70; H, 4.85; N, 7.15. $C_{23}H_{19}FN_2O_3$ (390.41) requires C, 70.76; H, 4.91; N, 7.18; ν = 1630 and 1610 (CO); δ_H ($CDCl_3$) = 3.89 (s, 3H), 6.93–8.23 (m, 13H), 11.71 (s, 1H), 12.53 (br.s, 1H), 12.69 (br.s, 1H); m/z (%) = 390(46.5) [M^+], 135(100).

Preparation of 2-benzoyl-3,3-bis(benzylamino)-2-propenal **14**: 2.8 g (0.01 mol) 2-benzoyl-3,3-bis(ethylthio)-2-propenal **1a** were dissolved in methanol. 2.14 g (0.02 mol) benzylamine were added to this solution and the reaction mixture was refluxed for 8 h. Evaporation of the solvent gave a yellow oil which crystallized by treatment with a few drops of ethanol. Yield 20%; m.p. 135–136.5°C (ethanol); Found (%) C, 77.49; H, 5.95; N, 7.49. $C_{24}H_{22}N_2O_2$ (370.45) requires C, 77.81; H, 5.99; N, 7.56; ν = 1640 and 1600 (CO); δ_H ($CDCl_3$) = 4.60 (d, 4H, J = 5.4), 7.22–7.47 (m, 15H), 9.28 (s, 1H), 11.73 (br.s, 2H); m/z (%) = 370(34) [M^+], 105(100).

Preparation of 2-benzoyl-1,1-bis(benzylamino)-3-(benzylimino)-propene **15**: 3.7 g (0.01 mol) 2-benzoyl-3,3-bis(benzylamino)-2-propenal **14** was treated with 1.60 g (0.015 mol) benzylamine in 80 ml dry methanol. The solution was refluxed for 10 h. The solvent was evaporated to give a solid which was filtered and recrystallized. Yield 43%; m.p. 115–117°C (ethanol); Found (%) C, 81.04; H 6.30; N, 9.12. $C_{31}H_{29}N_3O$ (459.60) requires C, 81.02; H, 6.36; N, 9.14; ν = 1610 (CO); δ_H ($CDCl_3$) = 4.32 (s, 2H), 4.59 (s, 4H), 7.29–7.76 (m, 20H), 8.15 (s, 1H), 12.50 (br.s, 2H).

Preparation of the 3-arylimino-2-(1,3-dithiolan-2-ylidene)-propiophenones **17a–e**: *General Procedure:* The experimental procedure was identical with that described for the preparation of 3-anilino-2-aroyl-3-(4-fluoroanilino)-2-propenales **13a,b** using 0.01 mol of the corresponding acylformylketene S,S-acetal **16a–d** and 0.02 mol aniline or 4-fluoroaniline, respectively.

2-(1,3-Dithiolan-2-ylidene)-3-phenylimino-propiophenone **17a**: Yield 65%; m.p. 152–154°C (ethanol); Found (%) C, 66.39; H, 4.66; N, 4.47; S, 19.70. $C_{18}H_{15}NOS_2$ (325.44) requires C, 66.43; H, 4.65; N, 4.30; S, 19.70; ν = 1620 (CO); δ_H ($CDCl_3$) = 3.38 (s, 4H), 7.03–7.66 (m, 10 H), 8.30 (s, 1H); m/z (%) = 325(20) [M^+], 105(100).

2-(1,3-Dithiolan-2-ylidene)-3-phenylimino-4'-bromopropiophenone **17b**: Yield 47%; m.p. 64–66°C (ethanol); Found (%) C, 53.23; H, 3.62; N, 3.53; Br, 19.68; S, 15.92. $C_{18}H_{14}BrNOS_2$ (404.34) requires C, 53.47; H, 3.49; N, 3.46; Br, 19.76; S, 15.86; ν = 1630 (CO); δ_H ($CDCl_3$) = 3.39 (s, 4H). 7.25–7.61 (m, 9H); 9.29 (s, 1H); m/z (%) = 403, 405(8) [M^+], 185(100).

2-(1,3-Dithiolan-2-ylidene)-3-phenylimino-4'-chloropropiophenone **17c**: Yield 41%; m.p. 97–99°C (ethanol); Found (%) C, 59.88; H, 3.95; N, 3.93; Cl, 9.79; S, 18.01. $C_{18}H_{14}ClNOS_2$ (359.89) requires C, 60.07; H, 3.92; N, 3.89; Cl, 9.85; S, 17.82; ν = 1630 (CO); δ_H ($CDCl_3$) = 3.40 (s, 4H), 7.28–7.61 (m, 9H), 8.30 (s, 1H); m/z (%) = 359(12) [M^+], 139(100).

2-(1,3-Dithiolan-2-ylidene)-3-(4-fluorophenylimino)-propiophenone **17d**: Yield 48%; m.p. 145–147°C (ethanol); Found (%) C, 62.91; H, 4.11; N, 4.16; S, 19.00. $C_{18}H_{14}FNOS_2$ (343.43) requires C, 62.95; H, 4.11; N, 4.08; S, 18.67; ν = 1600 (CO); δ_H ($CDCl_3$) = 3.39 (s, 4H), 6.97–7.72 (m, 9H), 8.30 (s, 1H); m/z (%) = 343 (17) [M^+], 105(100).

2-(1,3-Dithiolan-2-ylidene)-3-(4-fluorophenylimino)-4'-fluoropropiophenone **17e**: Yield 42%; m.p. 142–143°C (ethanol); Found (%) C, 59.69; H, 3.63; N, 3.86; S, 17.79. $C_{18}H_{13}F_2NOS_2$ (361.42) requires C, 59.82; H, 3.63; N, 3.88; S, 17.74; ν = 1615 (CO); δ_H ($CDCl_3$) 3.38 (s, 4H), 7.02–7.69 (m, 8H), 8.28 (s, 1H); m/z (%) = 361(6) [M^+], 123(100).

Preparation of the acylformylketene S,N-acetals **18a–d**: *General Procedure*: 0.02 mol of the corresponding acylformylketene S,S-acetal was dissolved in 200 ml of dry diethyl ether. The solution was treated with 0.02 mol of the secondary amine and the mixture was stirred at room temperature for 1 h. The precipitate was filtrated and recrystallized.

2-Benzoyl-3-ethylthio-3-morpholino-2-propenal **18a**: Yield 94%; m.p. 126–129°C (ethyl acetate); Found (%) C, 62.75; H, 6.28; N, 4.45; S, 10.56. $C_{16}H_{19}NO_3S$ (305.39) requires C, 62.93; H, 6.27; N, 4.59; S, 10.50; ν = 1640 and 1600 (CO); δ_H ($CDCl_3$) = 1.32 (t, 3H), 3.11 (q, 2H, J = 7), 3.90 (s, 8H), 7.35–7.59 (m, 5H), 9.28 (s, 1H).

2-(4-Methoxybenzoyl)-3-methylthio-3-morpholino-2-propenal **18b**: Yield 97%; m.p. 149–150°C (diethyl ether); Found (%) C, 59.57; H, 6.06; N, 4.26; S, 10.20. $C_{16}H_{19}NO_4S$ (321.39) requires C, 59.80; H, 5.96; N, 4.36; S, 9.98; ν = 1640 and 1605 (CO); δ_H ($CDCl_3$) = 2.51 (s, 3H), 2.81 (s, 3H), 3.83 (s, 8H), 6.86 (dd, 2H, J = 9 and 2), 7.51 (dd, 2H, J = 9 and 2), 9.31 (s, 1H); m/z (%) = 321(13) [M^+], 135(100).

2-(4-Methoxybenzoyl)-3-methylthio-3-pyrrolidino-2-propenal **18c**: Yield 91%; m.p. 169–170°C (methanol); Found (%) C, 62.66; H, 6.33; N, 4.57; S, 10.73. $C_{16}H_{19}NO_3S$ (305.39) requires C, 62.93; H, 6.27; N, 4.59; S, 10.50; ν = 1610 and 1600 (CO); δ_H ($CDCl_3$) = 2.10 (br.s, 4H), 2.55 (s, 3H), 3.76 (br.s, 4H), 3.82 (s, 3H), 6.87 (dd, 2H, J = 9 and 2), 7.54 (dd, 2H, J = 9 and 2), 9.22 (s, 1H); m/z (%) = 305(12.5) [M^+], 135(100).

2-(4-Methoxybenzoyl)-3-methylthio-3-piperidino-2-propenal **18d**: Yield 52%; m.p. 62–63°C (diethyl ether); Found (%) C, 63.95; H, 6.86; N, 4.21; S, 9.87. $C_{17}H_{21}NO_3S$ (319.42) requires C, 63.92; H, 6.63; N, 4.39; S, 10.03; ν = 1675 and 1600 (CO); δ_H ($CDCl_3$) = 1.76 (br.s, 4H), 2.09 (s, 3H), 2.51 (br.s, 6H), 3.81 (s, 3H), 6.86 (dd, 2H, J = 9 and 2), 7.53 (dd, 2H, J = 9 and 2), 9.25 (s, 1H); m/z (%) = 319(7) [M^+], 135(100).

Preparation of the heterocyclic compounds **19a–f, 20, 21,** *and* **22**: *General Procedure:* 0.01 mol of the corresponding acylformylketene S,S- or S,N-acetal and 0.01 mol of the 1,4- or 1,5-dinucleophile were heated under reflux in dry ethanol (40 ml) for 8 h. After cooling, the precipitate was filtered and recrystallized. Compounds **20** and **21** were separated by column chromatography (silica gel, $CHCl_3$) and compounds **19c** and **22** by fractional crystallization.

2-(Oxazolidine-2-ylidene)-3-oxo-3-phenyl-propanal **19a**: Yield 62%; m.p. 156–158°C (ethanol); Found (%) C, 66.38; H, 5.14; N, 6.17. $C_{12}H_{11}NO_3$ (217.22) requires C, 66.35; H, 5.10; N, 6.45; ν = 3300 (NH), 1665 and 1600 (CO); δ_H ($CDCl_3$) = 3.90 (t, 3H, J = 9), 4.73 (t, 2H, J = 9), 7.33–7.56 (m, 5H), 9.50 (s, 1H), 10.99 (br.s, 1H); m/z (%) = 217(34) [M^+], 105(100).

3-(Hexahydropyrimidine-2-ylidene)-3-oxo-3-phenyl-propanal **19b**: Yield 74%; m.p. 163–165°C (ethanol); Found (%) C, 67.77; H, 6.11; N, 12.22. $C_{13}H_{14}N_2O_2$ (230.27) requires C, 67.81; H, 6.13; N, 12.17; ν = 3250 (NH), 1630 and 1650 (CO); δ_H ($CDCl_3$) = 2.00 (quint., 2H, J = 5.7), 3.42 and 3.44 (dt, 4H), 7.37 (m, 5H), 9.20 (s, 1H), 10.70 (br.s, 1h); m/z (%) = 230(100) [M^+].

3-(4-Chlorophenyl)-2-(2,3-dihydro-benzimidazole-2-ylidene)-3-oxopropanal **19c**: Yield 58%; m.p. 295–297°C (DMF); Found (%) C, 64.21; H, 3.75; N, 9.47; Cl, 11.80. $C_{16}H_{11}ClN_2O_2$ (298.73) requires C, 64.33; H, 3.71; N, 9.38; Cl, 11.87; ν = 3210 (NH), 1625 and 1610 (CO); δ_H (DMSO-d_6) = 7.29–7.77 (m, 8H), 9.32 (s, 1H), 12.92 (br.s, 1H); m/z (%) = 298(67.5) [M^+], 269(100).

2-(2,3-Dihydro-benzimidazole-2-ylidene)-3-(4-methoxyphenyl)-3-oxopropanal **19d**: Yield 62%; m.p. 249–252°C (*n*-butanol); Found (%) C, 69.16; H, 4.72; N, 9.76. $C_{17}H_{14}N_2O_3$ (294.31) requires C, 69.38; H, 4.79; N, 9.52; ν = 3090 (NH), 1630 and 1610 (CO); δ_H ($CDCl_3$) = 3.88 (s, 3H), 6.92–7.66 (m, 8H), 9.61 (s, 1H), 12.85 (br.s, 1H); m/z (%) = 294(65) [M^+], 158(100).

3-(4-Chlorophenyl)-2-(2,3-dihydro-benzoxazole-2-ylidene)-3-oxopropanal **19e**: Yield 93%; m.p. 211–213°C (*n*-butanol); Found (%) C, 63.77; H, 3.79; N, 4.45; Cl, 11.76. $C_{16}H_{10}ClNO_3$ (299.71) requires 64.12; H, 3.36; N, 4.67; Cl, 11.83; ν = 3270 (NH), 1660 and 1625 (CO); δ_H (DMSO-d_6) = 7.15–8.09 (m, 8H), 9.28 (s, 1H); m/z (%) = 299(21) [M^+], 139(100).

2-(2,3-Dihydro-benzothiazole-2-ylidene)-3-oxo-3-phenyl-propanal **19f**: Yield 28%; m.p. 184–187°C (ethanol); Found (%) C, 67.92; H, 3.93; N, 5.09; S, 11.36. $C_{16}H_{11}NO_2S$ (281.33) requires C, 68.31; H, 3.94; N, 4.98; S, 11.40; ν = 3140 (NH), 1620 and 1590 (CO); δ_H ($CDCl_3$) = 7.36–7.87 (m, 9H), 9.60 (s, 1H), 12.73 (br.s, 1H); m/z (%) = 281(63) [M^+], 253(100).

2-(Imidazolidine-2-ylidene)-3-oxo-3-phenyl-propanal **20**: Yield 14%; m.p. 165–167°C (ethanol); Found (%) C, 66.64; H, 5.53; N, 12.89. $C_{12}H_{12}N_2O_2$ (216.24) requires C, 66.65; H, 5.59; N, 12.95; ν = 3385 (NH), 1630 and 1600 (CO); δ_H ($CDCl_3$) = 3.78 (s, 4H), 7.28–7.67 (m, 5H), 9.27 (s, 1H), 9.32 (br.s, 2H); m/z (%) = 216 (27) [M^+], 105(100).

N,N'-Bis-[2-benzoyl-1,1-bis(ethylthio)-propenylidene]-ethylene diamine **21**: Yield 24%; m.p. 120–122°C (ethanol); Found (%) C, 61.41; H, 6.22; N, 4.90; S, 22.05. $C_{30}H_{36}N_2O_2S_4$ (584.87) requires C, 61.61; H, 6.20; N, 4.79; S, 21.93; ν = 1680 (CO); δ_H ($CDCl_3$) = 1.04 (t, 3H, J = 7), 1.32 (t, 3H, J = 7), 2.71 (q, 2H, J = 7), 2.92 (q, 2H, J = 7), 3.59 (s, 2H), 7.52–7.87 (m, 5H), 8.54 (s, 1H).

2-Anilino-3-(4-chlorobenzoyl)-1,5-benzodiazepine **22**: Yield 27%; m.p. 220–222°C (*n*-butanol); Found (%) C, 70.76; H, 4.32; N, 11.11; Cl, 9.40. $C_{22}H_{16}ClN_3O$ (373.84) requires C, 70.68; H, 4.31; N, 11.24; Cl, 9.48; ν = 3325 (NH), 1620 (CO); δ_H ($CDCl_3$) = 3.95 (br.s, 1H); 6.79–7.77 (m, 13H), 8.04 (s, 1H), 11.91 (br.s, 1H); m/z (%) = 373(65) [M^+], 139(100).

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