

Polarised Ketene Dithioacetals. Part 32.¹ Studies on Base-catalysed Rearrangements of 2-Bis(methylthio)methyleneindan-1-one, 2-Bis(methylthio)methylene-1-tetralone, and 3-Bis(methylthio)methylene-2,3-dihydro-1-benzothiopyran-4-one

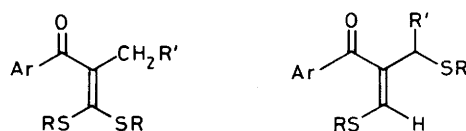
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The ketene dithioacetal (**7**) derived from indan-1-one gave a dimeric product (**8**) on treatment with sodium hydride in dimethylformamide under nitrogen. The dithioacetal (**15**) derived from 1-tetralone on prolonged treatment with sodium hydride under identical conditions yielded the corresponding methyl β -oxodithioester (**16**) and the *S*-methyl β -oxothioester (**17**). Under similar conditions, the dithioacetal (**28**) derived from 2,3-dihydro-1-benzothiopyran-4-one gave the expected rearranged product (**29**) formed by a 1,3-methylthio shift. The structural assignments of the products (**8**), (**16**), (**17**), and (**29**) and the probable mechanism for the formation of (**8**), (**16**), and (**17**) are described.

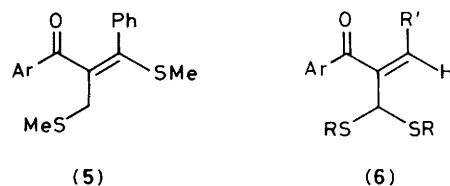
In our recent publication,^{2,3} we showed that the α -oxoketene dithioacetals (**1**) derived from propiophenones undergo a facile base-catalysed rearrangement to give the corresponding 3-alkylthio-2-alkylthiomethylacrylophenones (**2**). Similarly, the acetal (**3**) derived from dihydrochalcone yielded a mixture of the products (**4**) and (**5**) in 30 and 50% yield, respectively, under nitrogen; in the absence of nitrogen, however products derived from the oxidative cleavage of (**3**) were obtained as well as compounds (**4**) and (**5**). These rearrangements were explained by the mobile oxoallyl intermediate (**6**), which on subsequent Michael addition and allylic displacement of an alkylthiolate anion yields either product (**2**) or (**4**). The product (**4**) undergoes a 1,3-prototropic shift to give the thermodynamically more stable form (**5**) under the reaction conditions. When these studies were extended to the ketene dithioacetals (**7**), (**15**), and (**28**), derived from indan-1-one, 1-tetralone (1,2,3,4-tetrahydronaphthalen-1-one), and 2,3-dihydro-1-benzothiopyran-4-one respectively, the reaction did not follow the same course of rearrangement, except in the case of the thiopyranone (**28**). Thus, under these reaction conditions, only the dimer (**8**) was isolated from the indan-1-one (**7**), in 45% yield, while a mixture of the dithioate (**16**) and the thioate (**17**) was obtained from the tetralone (**15**) in 35 and 20% yield, respectively. The acetal (**28**), on the other hand, yielded the expected rearranged product (**29**). We report in this paper the structural assignments and the mechanism governing the formation of these products.

Results and Discussion

When the indanone dithioacetal (**7**) was treated with sodium hydride in dimethylformamide at room temperature, no well defined crystalline product could be isolated, despite the complete disappearance of the starting material. However, when this reaction was carried out under nitrogen, a light orange amorphous solid was isolated by preparative t.l.c. in 45% yield. The product thus formed was assigned the dimeric structure (**8**) on the basis of the analytical and spectral data. It showed in its mass spectrum the molecular ion peak at m/z 394 (78%) and was analysed for $C_{22}H_{18}S_2O_3$. The intense peak at m/z 346 (100%) was due to the loss of MeSH, and the other peak at m/z 329 (85%) was due to the combined loss of MeSH and an OH group, which indicates the presence of an OH group in (**8**). Its i.r. spectrum (KBr) exhibited bands at 3 415 (br, OH), 1 718 (CO), and 1 680 cm^{-1} (conjugated CO), which further supports the structure (**8**). The n.m.r. spectrum ($CDCl_3$) showed two singlets at δ 2.20 (3 H) and 2.78 due to two SMe groups,



- (1) $R' = H$, $R = Me$ or Et
 (3) $R' = Ph$, $R = Me$
- (2) $R' = H$, $R = Me, Et$
 (4) $R' = Ph$, $R = Me$



- (5)
- (6)
 a: $R' = H$, $R = Me, Et$
 b: $R' = Ph$, $R = Me$

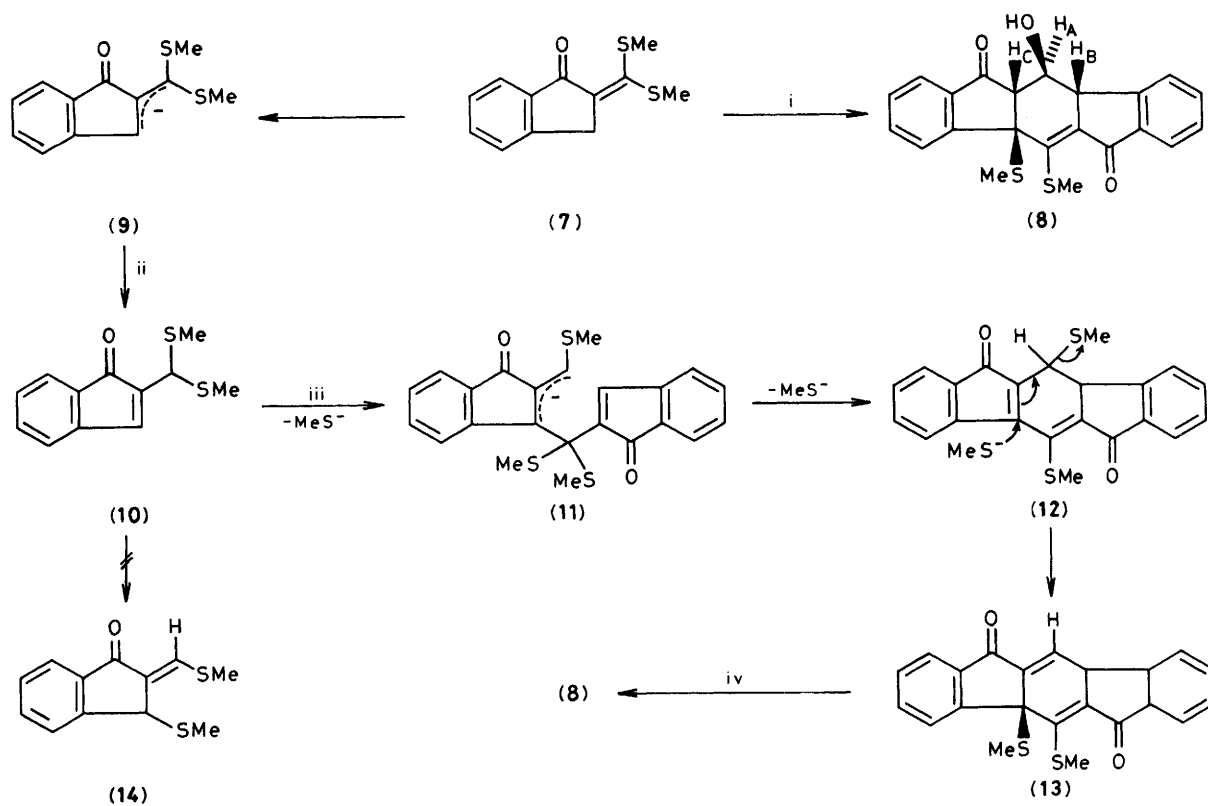
attached to sp^3 and sp^2 carbon atoms, respectively. All eight aromatic protons appeared as a broad multiplet at δ 7.30–8.21, while the multiplicity and the characteristic coupling constants of the three methine protons at δ 4.52 (br t, J 7 Hz, H_A), 3.88 (d, J 7 Hz, H_B), and 3.35 (d, J 7 Hz, H_C) are consistent with both their positional assignments and the proposed stereochemistry.*†

The probable mechanism for the formation of the dimer (**8**) is shown in Scheme 1. Apparently, the allyl anion (**9**) and the rearranged intermediate (**10**) undergo Michael addition followed by allylic displacement of the methylthio group and proton abstraction to yield the dimeric anion (**11**). The anion (**11**), on subsequent cyclisation and displacement of the methylthio group, gives the polycyclic compound (**12**). The concomitant allylic addition and elimination of the methylthiolate anion in (**12**) yields (**13**) which on hydration gives the product (**8**). The hydration of the intermediate (**13**) appears to be due to its electron deficient nature and the release of the strain due to the exocyclic double bond.

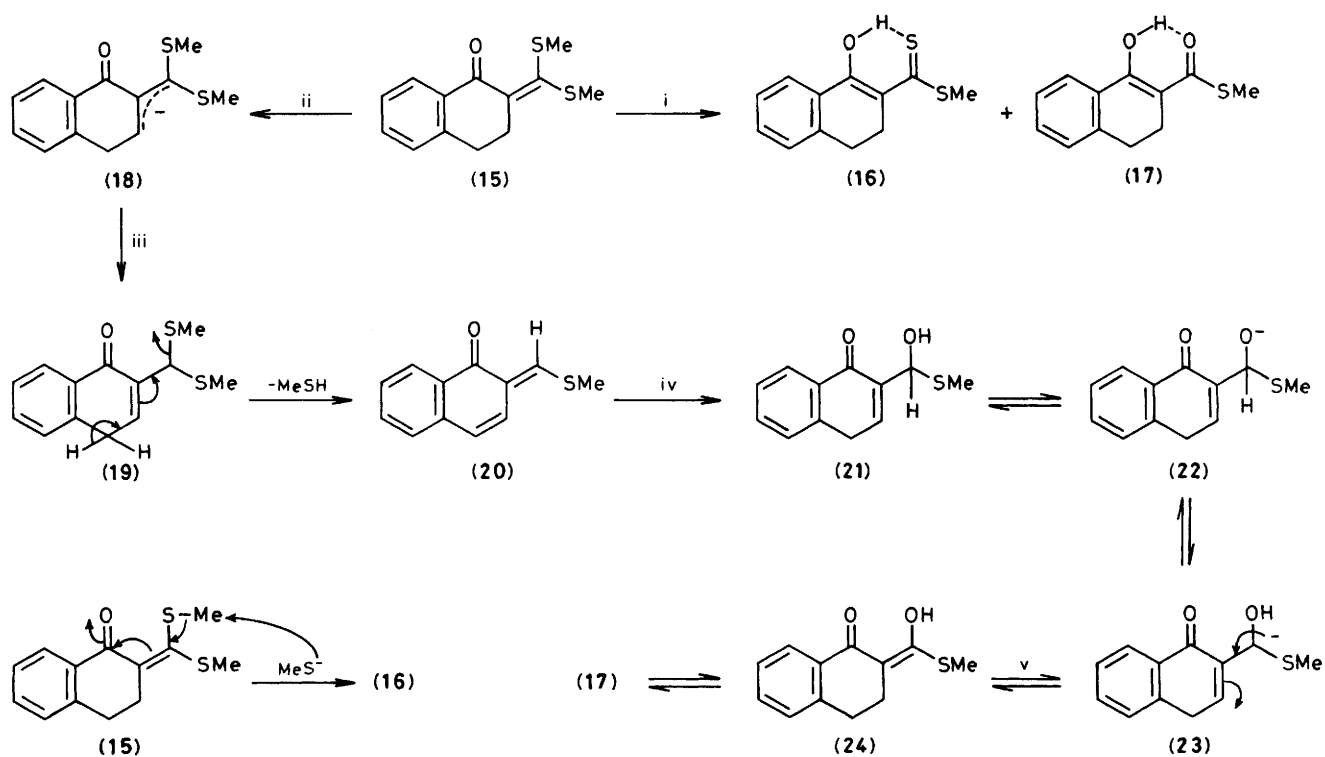
When the tetralone (**15**) was treated with sodium hydride under similar reaction conditions for 3 h, unchanged starting

* Construction of Dreiding models show that H_C and MeS are *cis* to each other in the most stable conformation.

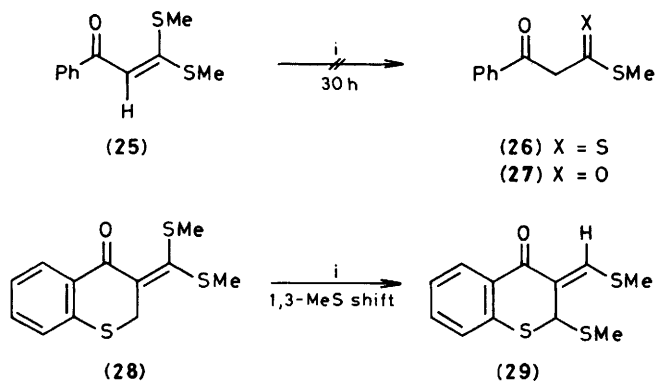
† Compound (**8**) was not soluble enough in $CDCl_3$ and other solvents for a ^{13}C n.m.r. spectrum to be obtained; it was not stable in $(CD_3)_2SO$ and gave a complex 1H n.m.r. spectrum.



Scheme 1. Reagents: i, NaH, DMF; ii, (7); iii, (9); iv, H₂O



Scheme 2. Reagents: i, NaH, DMF; ii, B; iii, (15); iv, OH⁻; v, H⁺



Scheme 3. Reagents: i, NaH, DMF; 30 h

material was recovered. However, when the reaction time was prolonged for 30 h, a mixture of the dithioester (16) (35%) and the monothioester (17) (20%) was isolated after work-up; these were separated by column chromatography. The dithioester (16) was reported earlier⁴ and its m.p., i.r., and n.m.r. data were identical with those of an authentic sample. The structure of compound (17) was confirmed by its analytical and spectral data (Experimental section). The same products (16) and (17) were obtained in 40 and 30% yields, respectively, when the tetralone (15) was treated with sodium hydride under nitrogen.

The formation of products (16) and (17) appears to involve demethylation and hydrolytic cleavage of compound (15), respectively. However other ketene dithioacetals, such as (25), remained unchanged under identical conditions and the formation of either the dithioester (26) or the *S*-methyl ester (27) was not observed. The probable mechanism governing the formation of (16) and (17) is shown in Scheme 2. The intermediate (19) formed *via* the anion (18) undergoes base-catalysed elimination of the methylthio group to give the tetralone (20) which during work-up undergoes nucleophilic attack by hydroxide ion to give the alcohol (21). The intermediate (21), *via* a series of sequential proton transfers [(21) \rightleftharpoons (22) \rightleftharpoons (23) \rightleftharpoons (24)] yields the *S*-methyl ester (17). The formation of (16) could also be explained by demethylation of (15) by methanethiolate anion (generated *in situ*). Such demethylation of oxoesters by alkanethiolate anions is reported in the literature.⁵

Under similar conditions, the acetal (28) gave the expected rearranged product (29) *via* a 1,3-methylthio shift, as described earlier (Scheme 3). The structure of compound (29) was confirmed with the help of the spectral and analytical data.

Experimental

M.p.s were determined on a Boetius apparatus and are uncorrected. I.r. spectra were recorded on a Perkin-Elmer 297 spectrophotometer, while the ¹H n.m.r. spectra were obtained on a Varian EM-390 90 MHz spectrometer using SiMe₄ as internal reference. In all the reactions a 50% suspension of sodium hydride was used.

Starting Materials.—The unknown ketene dithioacetal (7) and the known ketene dithioacetals (15)⁶ and (28)⁷ were prepared according to the method reported earlier by condensation of the respective ketones with carbon disulphide in the presence of sodium *t*-butoxide (2 equiv.) followed by treatment with methyl iodide. 2-Bis(methylthio)methyleneindan-

1-one (7) was obtained as yellow shining needles (70%) after purification by column chromatography over silica gel using hexane-ethyl acetate (9:1) as eluant; m.p. 70–71 °C; ν_{\max} (KBr) 1 663 cm⁻¹ (CO); δ (CCl₄) 2.52 (s, 3 H, SCH₃), 2.55 (s, 3 H, SCH₃), 3.78 (s, 2 H, CH₂), and 7.30–7.90 (m, 4 H, arom); m/z 236 (*M*⁺) [Found: C, 61.5; H, 5.4. C₁₂H₁₂OS₂ requires (*M* 236) C, 61.02; H, 5.08%].

Reaction of the Dithioacetal (7) with Sodium Hydride.—A solution of (7) (2.4 g, 0.01 mol) in dry dimethylformamide (20 ml) was added dropwise (15 min) to a stirred suspension of sodium hydride (0.04 mol) in dimethylformamide (30 ml) at 50–55 °C under nitrogen. After being stirred for a further 1 h the reaction mixture was poured over crushed ice (*ca.* 200 g), neutralized with dilute acetic acid, extracted with ethyl acetate (2 × 100 ml), washed with water (3 × 100 ml), dried, and the solvent evaporated to give a red viscous residue. This was purified by preparative t.l.c. on a silica gel plate using ethyl acetate as the mobile phase (*R_F* *ca.* 0.4) to give the dimeric product (8) (0.81 g, 45%) as a light orange amorphous solid, m.p. 194–195 °C (ethyl acetate); spectral data given in text [Found: C, 67.4; H, 4.8. Calc. for C₂₂H₁₈O₃S₂ (*M* 394): C, 67.01; H, 4.57%]. Attempts to purify (8) by column chromatography led to its decomposition.

Reaction of 2-Bis(methylthio)methylene-1-tetralone (15) with Sodium Hydride.—To a stirred suspension of sodium hydride (0.04 mol) in dry dimethylformamide (20 ml) at 50–55 °C, a solution of (15) (2.5 g, 0.01 mol) in dry dimethylformamide (10 ml) was added and the reaction mixture was stirred at 50–60 °C for 30 h till the starting material had disappeared completely (t.l.c.). Work-up of the reaction mixture as described above gave a bright orange viscous residue which was purified by column chromatography over silica gel. Elution with hexane gave methyl 3,4-dihydro-1-hydroxydithio-2-naphthoate (16) (0.8 g, 35%) as a bright yellow solid, m.p. 77–78 °C (lit.,⁴ m.p. 78–79 °C) (superimposable i.r. and n.m.r. spectra, mixed m.p.). Further elution with hexane yielded *S*-methyl 3,4-dihydro-1-hydroxythio-2-naphthoate (17) (0.45 g, 20%) as light yellow prisms, m.p. 63–64 °C; ν_{\max} (Nujol) 3 300 and 1 620 cm⁻¹; δ (CCl₄) 2.40 (s, 3 H, SCH₃), 2.85–3.15 [m, A₂B₂, 4 H, (CH₂)₂], 7.10–7.25 (m, 3 H, arom), and (7.70–7.85 (m, 1 H, arom); m/z 220 (*M*⁺) [Found: C, 65.7; H, 5.8. Calc. for C₁₂H₁₂O₂S (*M* 220): C, 65.45; H, 5.45%].

Reaction of 3,3-Bis(methylthio)-1-phenylprop-2-en-1-one (25) with Sodium Hydride.—The acetal (25) (1.12 g, 0.005 mol) was treated with sodium hydride (0.02 mol) under conditions identical with those for (15) for 30 h. The reaction mixture after the usual work-up gave unchanged compound (25) (1.0 g, 90%) (mixed m.p., superimposable i.r. and n.m.r.) and no trace of the thioate (26) or the dithioate (27) was detected (t.l.c.).

Reaction of 3-Bis(methylthio)methylene-2,3-dihydro-1-benzothiopyran-4-one (28) with Sodium Hydride.—A solution of (28) (2.68 g, 0.01 mol) in dry dimethylformamide (10 ml) was added to a suspension of sodium hydride (0.02 mol) in dry dimethylformamide (20 ml) at room temperature and the reaction mixture was further stirred for 5 h. Work-up of the reaction mixture as described above yielded a crude solid which on recrystallisation from ethyl acetate-hexane (1:9) yielded 2-methylthio-3-methylthiomethylene-2,3-dihydro-1-benzothiopyran-4-one (29) (1.60 g, 60%) as pale yellow needles, m.p. 108–109 °C; ν_{\max} (KBr) 1 615 cm⁻¹; δ (CDCl₃) 2.10 (s, 6 H, 2 SCH₃), 5.40 (s, 1 H, methine), 7.45–7.55 (m, 3 H, arom), 8.07 (s, 1 H, vinylic), and 8.45–8.60 (m, 1 H, arom); m/z 268 (*M*⁺) [Found: C, 53.6; H, 4.3. C₁₂H₁₂S₃O (*M* 268) requires C, 53.73; H, 4.48%].

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