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THE REACTION OF CYCLIC ß-DIKETONES WITH TRIFLUOROMETHYLSULPHENYL CHLORIDE

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SUMMARY

The reactions of cyclic ß-diketones with trifluoromethylsulphenyl chloride were carried out to give the corresponding CF_3S-substituted derivatives. Oxidation of the CF_3S-substituted dimedone led to ring cleavage. The CF_3SO_2-substituted dimedone was prepared by reaction of trifluoromethylsulphonyl chloride with the metallated ß-diketone.

INTRODUCTION

α-Trifluoromethylsulphenylation of various enolates has been rather widely studied recently in searching for new synthetic routes to fluorine-containing compounds [1,2]. One of the standard methods for introducing R_fS-groups into organic molecules involves the reaction of trifluoromethylsulphenyl chloride with active methylene compounds [1-3]. This method has been used in reactions with acyclic ketones, diketones, ß-ketoesters and their derivatives. Cyclic ß-diketones such as dimedone have never been subjected to this reaction although fluorine-containing compounds of that type could be of interest as practically useful synthones.

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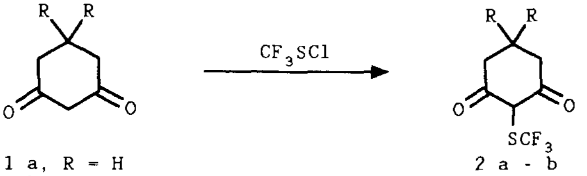
In the present paper, results of an examination of the reaction of 1,3-cyclohexanedione (**1a**) 5,5-dimethyl-1,3-cyclohexanedione (dimedone) (**1b**), and 1,3-indanedione with trifluoromethylsulphenyl chloride are summarized.

RESULTS AND DISCUSSION

It has been found that the direct introduction of a CF_3S-substituent into the active methylene group of the compounds **1a** and **1b** by means of CF_3SCl proceeds smoothly in the presence of pyridine in chloroform producing in good yields the monosubstituted products **2a** and **2b**. The yield does not depend on the molecular ratio of the reagents. Even in the case of a substantial excess of CF_3SCl, only **2a** and **2b** have been obtained. All attempts to force these products to react again with CF_3SCl failed.

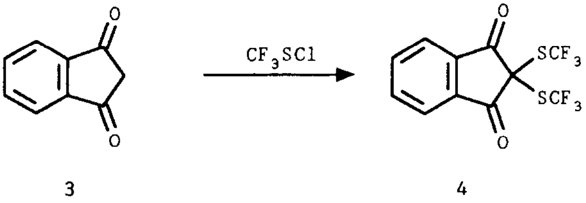


1 a, R = H
b, P = Me

2 a - b

Such selectivity is not typical for analogous reactions of alkylsulphenyl chlorides [4], but is in a good accord with results of trifluoromethylsulphenylation of acyclic ß-diketones by CF_3SCl [1], where the monosubstituted derivatives were also the only products. This phenomenon has been explained by the rather high electronegativity of the CF_3S-substituent (2.7[5]) that causes a shift of the tautomeric equilibrium in the direction of the enolic form. The same pictu was observed in the case of cyclic ß-diketones, e.g. the ^1H NMR spectrum of **1a** taken in $CDCl_3$ at room temperature shows the presence of about 30 % enolic form whereas its 2-trifluoro-methylthio analogue exists under those conditions exclusively in the enol form.

In contrast, 1,3-indanedione (3), containing a five-membered ß-diketone ring, reacts with CF_3SCl under the same conditions with formation of bis(trifluoromethylthio) substituted product **4** only,



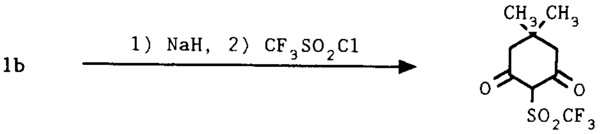
Even when the reagents have been brought together in a molar ratio of 1:1, **4** has been isolated in 41% yield and only traces of the monosubstituted derivative (monitored by ^{19}F NMR) have been found. Such course of the reaction may be eventually explained by the influence of the π-electron system of the aromatic ring. As seen from the structural formula, **4** can exist only in the diketone form as shown by ^1H NMR- and IR-spectra.

It was mentioned earlier [1] that introduction of a CF_3S group into the active methylene group of ß-diketones increases the stability of the CF_3S-substituted derivatives in comparison with the unsubstituted ones. This was also found for the CF_3S-substituted cyclic ß-diketones. So, e.g. compound **2b** was isolated unchanged after 12 hours boiling in 20% sulfuric acid, although in the case of the corresponding nitro derivative, ring opening is observed under much milder conditions [6].

The CF_3S group in cyclic ß-diketones blocked by two carbonyl groups is especially resistant to oxidation. All attempts to convert it into a CF_3SO_2 group failed. In the case of chromium trioxide/acetic acid, trifluoroperacetic acid and potassium peroxomonosulfate (Oxon, 'Janssen Chimica'), complete destruction of the ß-carbonyl ring was observed. When **2b** was treated with 30% hydrogen peroxide in acetic acid at room temperature, no oxidation was observed (monitored by thin-layer chromatography and ^{19}F NMR spectroscopy). At 50°C, we could see the formation of CF_3SO_2 substituted products by

NMR, but the only solid compound isolated after working up the reaction mixture was 3,3-dimethylglutaric acid.

The CF_3SO_2 substituted dimedone **6** was accessible by reaction of trifluoromethylsulphonyl chloride with metallated **1b**.



6

The mixture of reagents in THF was stirred at 80°C overnight and **6** was isolated by thin-layer chromatography in 31% yield. It is not thermally stable and decomposes when heated to melting.

The structures of compounds investigated were fully confirmed by means of elemental analyses, IR-, ^1H- and ^{19}F-NMR spectra.

EXPERIMENTAL

Melting points are not corrected. ^1H and ^{19}F NMR spectra were recorded in $CDCl_3$, using TMS and $CFCl_3$ as internal standards, respectively, with a Bruker HX 60/5 spectrometer. Positive chemical shift values of ^{19}F are upfield from $CFCl_3$. IR spectra were measured in KBr pellets with a Perkin-Elmer 398 Infrared Spectrophotometer.

2-(Trifluoromethylthio)-1,3-cyclohexanedione (2a)

To a mixture of **1a** (5.6 g, 0.05 mole) and pyridine (4.35 g, 0.055 mole) in 50 ml of dry chloroform in a glass pressure vessel fitted with a PTFE valve, CF_3SCl (7.48 g, 0.055 mole) was condensed. The reaction mixture was stirred overnight at room temperature, poured into water, and neutralized with an aqueous solution of sodium carbonate, washed thoroughly with water, and dried over magnesium

sulphate. After removal of the solvent, the product was crystallized from a benzene-hexane (1:1) mixture (7.52g, 71% yield). M.p. 115-116°C. Analysis calc. for $C_7H_7F_3O_2S$: C, 39.0; H, 3.3; S, 14.9; found: C, 39.3; H, 3.2; S, 14.9.
^1H NMR δ (ppm): 2.15 m (CH_2), 2.54 t ($COCH_2$), 7.6 (OH).
^{19}F NMR δ (ppm): 45.18 s (CF_3S). IR (cm^{-1}): 2990 m (CH aliph), 2710 b (OH), 1670 s (C=O ketone),
1270 s (C-O), 1120-1165 s (C-F).

2-(Trifluoromethylthio)-5,5-dimethyl-1,3-cyclohexanedione (2b)

Compound **2b** was prepared analogously to compound **2a** from **1b** and CF_3Cl in 86% yield, m.p. 145-146°C (benzene-hexane). Analysis calc. for $C_9H_{11}F_3O_2S$: C, 45.0; H, 4.6; S, 13.3; found: C, 45.2; H, 4.2; S, 13.5.
^1H NMR δ (ppm) 1.1 s (CH_3), 2.5 s (CH_2), 7.3 (OH).
^{19}F NMR δ (ppm) 45.47 s (CF_3S).
IR (cm^{-1}) 2980 m (CH aliph), 2705 b (OH), 1675 s (C=O ketone), 1260 s (C-O), 1120-1155 s (C-F).

2,2-Bis(trifluoromethylthio)-1,3-indanedione (4)

Compound 4 was synthesized analogously to **2a** from 3 (0.02 mole) and CF_3Cl (0.044 mole) in 73% yield, m.p. 80-82°C (hexane). Analysis calc. for $C_{11}H_4F_6O_2S_2$: C, 38.2; H, 1.2; S, 18.5; found: C, 38.3; H, 1.1; S, 17.9
^1H NMR δ (ppm) 8.13 m (aromatic).
^{19}F NMR δ (ppm) 47.80 s (CF_3S).
IR (cm^{-1}) 3065 m (arom), 1675 s (C=O), 1150-1110 s (C-F), 775-740 m (CH arom).

Oxidation of 2-(trifluoromethylthio)-5,5-dimethyl-1,3-hexanedione (2b)

A solution of **2b** (1.2 g, 0.005 mole) and 30% hydrogen peroxide (3 ml) in acetic acid (8 ml) was stirred at 60°C for 12 hrs until no traces of **2b** could be detected by TLC and ^{19}F NMR spectroscopy in the reaction mixture. The solution was poured into water after which the products were extracted with ether. The organic layer was washed with water and dried over magnesium sulphate. After removal of the solvent, the crude residue was recrystallized from benzene. The physical constants and the spectral data of the obtained product were identical to that of 2,2-dimethylglutaric acid.

2-(Trifluoromethylsulphonyl)5,5-dimethyl-1,3-cyclohexanedione (6).

A suspension of **1b** (2.8 g, 0.02 mole), sodium hydride (0.18 g, 0.02 mole) and dry dioxane (30 ml) was placed into a 250 ml glass pressure vessel fitted with a PTFE valve. The mixture was stirred with a magnetic stirrer for 2 hrs at room temperature. Then, CF_3SO_2Cl (3.4 g, 0.02 mole) was condensed into the mixture and stirred at 80°C for 24 hrs. After cooling, the suspension was poured into water and extracted several times with ether. The combined organic layer was washed with $NaHCO_3$ solution and dried over magnesium sulphate. After evaporation of the solvent, product **6** was isolated in 21% yield by column chromatography on silica-gel Type JC 46 using chloroform as eluent. M.p. 167°C (benzene). Analysis calc. for $C_9H_{11}F_3O_4S$: C, 39.7; H, 4.0; found: C, 39.6; H, 3.9.

^1H NMR δ (ppm): 1.15 s (CH_3), 2.63 s (CH_2), 9.8 (OH).

^{19}F NMR δ (ppm): 76.1 s (CF_3SO_2).

IR (cm^{-1}): 2870-2840 m (CH aliph), 2740 b (OH), 1645 s (C=O), 1330-1300 s (SO_2), 1240 (C-O), 1130-1140 (C-F).

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REFERENCES

1 A.Kolasa, J.Fluorine Chem., 36 (1987) 29.

2 W. Zankowska-Jasinska, B.Zaleska and A.Haas, J.Fluorine Chem., 24 (1984) 363.

3 H.Bayreuther and A.Haas, Chem. Ber., 106 (1973) 1418.

4 E.Kühle, 'The Chemistry of the Sulphenic Acids 2', Georg Thieme, Stuttgart (1973) p. 95.

5 J.J.Lagowski, Quart. Rev., 13 (1959) 233.

6 O.Neilands, J.Skuja and Z.Laizane, Latv. PSR Zinat. Akad. Vestis, kim. ser., (1970) 2445. Chem.Abstr., 73 (19 24966c.