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Synthesis and Some Reactions of 1-(Trimethoxymethyl)cyclohexene

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1-(Trimethoxymethyl)cyclohexene (11) was synthesized in three steps from *N*-methyl-*N*-phenylcyclohex-1-ene-1-carboxamide (8). Reaction of the α,β-unsaturated ortho ester (11) with sodium hydride and *N*-methylaniline gave a 1 : 1 mixture of methyl cyclohex-1-ene-1-carboxylate (15) and *N*,*N*-dimethylaniline. Treatment of (11) with 3-methoxyphenol gave 1-[dimethoxy(3′-methoxyphenoxy)methyl]cyclohexene (10) which underwent thermolysis at 250° to give 1,3-dimethoxybenzene (16) and methyl cyclohex-1-ene-1-carboxylate (15).

Introduction

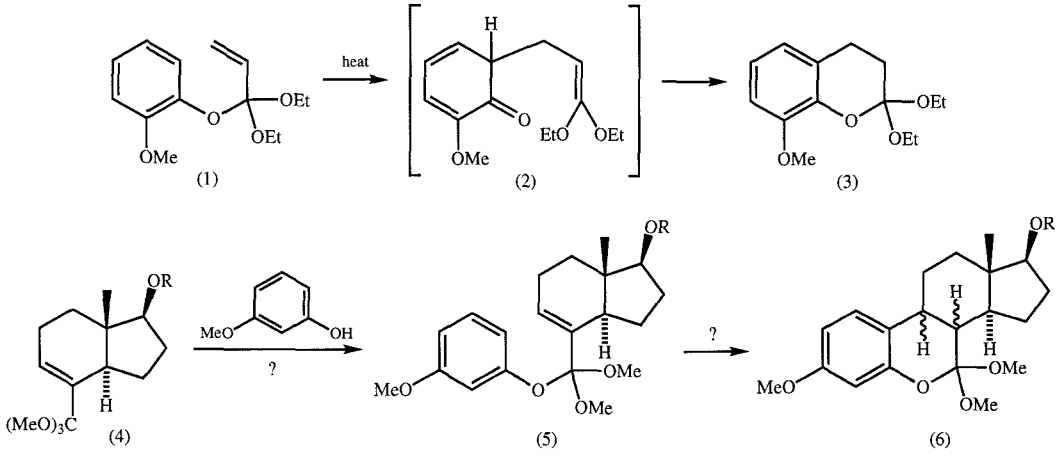
Panetta and Rapoport[1] reported that the reaction of an excess of trimethyl orthoacrylate with 2-methoxyphenol in the presence of pivalic acid gave the coumarinoid ortho ester (3) in almost quantitative yield. The initial transesterification product (1) undergoes a Claisen-type rearrangement to give the intermediate ketene acetal (2), which upon prototropic cyclization affords the ortho ester (3) (Scheme 1). In parallel with a more conventional route which we used to synthesize the $8\beta,9\alpha$-diastereomer of the 6-oxasteroidal ortho ester (6),[2] we explored the feasibility of generating (6) by reaction of the α,β-unsaturated ortho ester (4) with 3-methoxyphenol. A critical factor in the hypothetical cyclization of (5) → (6) is the stereochemistry of the ring junction in (6) which can exist in four C8,C9 diastereomers; such a reaction would only be useful if it led to 8βH,9αH stereochemistry.

As a model study we synthesized the simpler cyclohexene ortho ester (11) (Scheme 2) in order to study its reaction with 3-methoxyphenol. If the expected transesterification product (10) underwent cyclization to give (13) with a *trans* ring junction this would offer some encouragement for the pursuit of (4), although a parallel stereochemical outcome cannot be assumed.

In this paper we report the synthesis of 1-(trimethoxymethyl)cyclohexene (11) and its conversion into the mixed ortho ester (10) which underwent thermally induced fragmentation rather than cyclization.

Results and Discussion

The pathway chosen for generation of the α,β-unsaturated ortho ester (11) is an adaptation of the procedure used by McClelland *et al.*[3] for synthesis of aryl ortho esters via *N*-methyl *N*-phenyl amide acetals (Scheme 2). Reaction of cyclohexane-



Scheme 1

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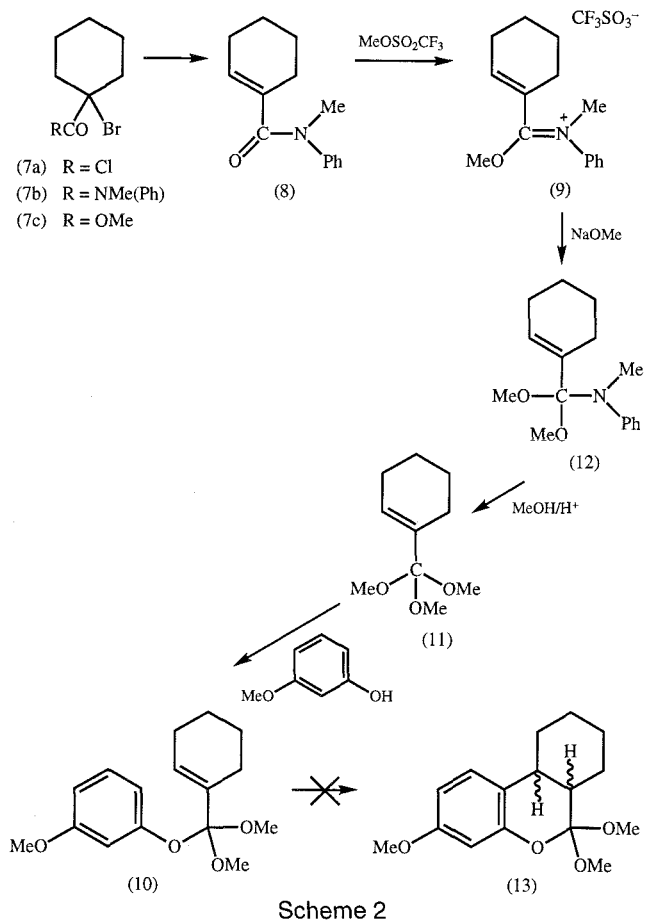
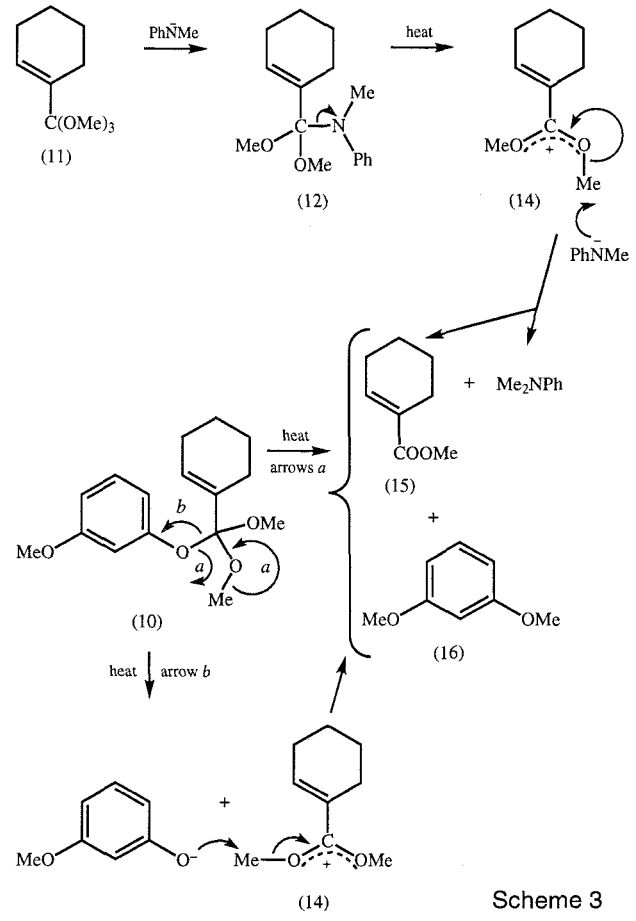


Scheme 2

carbonyl chloride with bromine and red phosphorus gave 1-bromocyclohexanecarbonyl chloride (7a), treatment of which with *N*-methylaniline in the presence of triethylamine afforded the bromo amide (7b). Dehydrobromination of (7b) with quinoline at 120° gave 92% of the α,β-unsaturated amide (8) which was treated with methyl trifluoromethanesulfonate to give the alkoxymethylene iminium salt (9); reaction of this with sodium methoxide in methanol produced the crude amide acetal (12). This was not isolated, but treated directly with methanol containing glacial acetic acid. Chromatography of the crude product followed by bulb-to-bulb distillation gave 68% of 1-(trimethoxymethyl)cyclohexene (11). The ^{1}H n.m.r. spectrum of (11) showed a nine-proton singlet at 3·13 ppm for the three methoxy groups. The ^{13}C n.m.r. spectrum showed the ortho ester carbon atom at 114·5 ppm, and signals at 131·8 and 129·3 ppm for C 1 and C 2, respectively.

The crude ortho ester (11) was contaminated with varying amounts of the unsaturated amide (8), methyl cyclohex-1-ene-1-carboxylate (15) and *N*-methylaniline. While the amide (8) and the ester (15) could be readily removed by distillation, removal of *N*-methylaniline was a problem. In an attempt to remove *N*-methylaniline as its non-volatile sodium salt, sodium hydride and tetrahydrofuran were added to a 1 : 1 mixture of (11) and *N*-methylaniline, and the mixture was heated under reflux. This resulted in the formation of equal quantities of *N*,*N*-dimethylaniline and the methyl ester (15). A rationalization of this is shown in Scheme 3. Presumably, the allylic nature of the ortho ester (11) makes it susceptible to nucleophilic displacement by the *N*-methylanilide ion to give the amide acetal (12). Compounds analogous to (12) have been found to undergo thermal dissociation to give reactive alkylating species.[4] Thermal fragmentation of compound (12) would give the dimethoxycarbenium ion (14), and attack of the *N*-methylanilide anion on this would produce a mixture of *N*,*N*-dimethylaniline and the methyl ester (15). Reports of reactions between ortho esters and secondary amines, without an added catalyst, to give the corresponding amide acetals are rare. McElvain and Tate[4] found that prolonged heating of a mixture of triethyl orthoacetate and dibutylamine at 200–220° gave the corresponding amide acetal as the major product. Similar reactions have been carried out with sulfonamides.[5,6] Of course, in our case the *N*-methylanilide ion is a better nucleophile than the parent amine, and the allylic nature of the ortho ester (11) increases both the polarizability of a C–OMe bond, and the stability of the derived dimethoxycarbenium ion (14).

Because the cyclohexene ortho ester (11) was most readily obtained as a 1 : 1 mixture with *N*-methylaniline,



Scheme 3

this was initially used in reactions of (11) with 3-methoxyphenol: the mixture was refluxed in toluene together with 1·5 mol. equiv. of pivalic acid to give a 3·5:1 mixture of the amide (8) and the ester (15), respectively. This indicates that the predominant reaction is the formation of the ester (15) via the dimethoxycarbenium ion (14): this reactive intermediate (methylating agent) is also responsible for the formation of methyl pivalate and of *N*,*N*-dimethylaniline, both of which were detected in the reaction mixture. The amide (8) is formed by reaction of the methyl ester (15) with *N*-methylaniline during the 20 h reaction time. This result made it necessary to obtain the ortho ester (11) as pure as possible, and several successive distillations of the crude ortho ester (11) through a spinning-band column gave material containing only about 5% of *N*-methylaniline, and this was used in subsequent experiments. An analytical sample of (11) was obtained by chromatography of the enriched material over basic alumina, but this was wasteful on a preparative scale.

Reaction of the 95% pure ortho ester (11) with 3-methoxyphenol in toluene containing 0·5 mol. equiv. of pivalic acid, and slow azeotropic removal of the methanol liberated, gave a mixture of the ester (15), the amide (8), starting material (11) and the desired mixed ortho ester (10) in the ratio 13:1:4:6·5; none of the tricyclic ortho ester (13) was detected. The detection of a small amount of methyl pivalate in the product promoted the use of the less nucleophilic methanesulfonic acid, but this was also methylated by reaction with the dimethoxycarbenium ion (14). The mixed ortho ester (10) was best obtained by heating a mixture of (11) and 3-methoxyphenol with slow distillation of the methanol produced.

Distillation of the mixed ortho ester (10) at atmospheric pressure gave none of the tricyclic ortho ester (13), but resulted in pyrolytic cleavage with methyl transfer to give 1,3-dimethoxybenzene (16) and the unsaturated ester (15). This cleavage is probably heterolytic (Scheme 3, arrow *b*), the 3-methoxyphenolate anion so produced being methylated by the dimethoxycarbenium ion (14), but a concerted process (Scheme 3, arrows *a*) cannot be excluded.

The pyrolytic cleavage reaction of (10) → (15)+(16) signalled a similar probable fate for the analogous *a*,*β*-unsaturated ortho ester (5), so the synthesis of this via (4) was not pursued, and the 6-oxasteroidal ortho ester (6) was synthesized by another route.[2]

Experimental

Melting points and boiling points are uncorrected. Bulb-to-bulb distillations were carried out with a Buchi GKR-50 tube oven, and only oven temperatures are given. Microanalyses were performed by Chemical and Micro Analytical Services Pty Ltd, Melbourne. Infrared spectra were measured with a Perkin–Elmer 1600 FT-IR spectrophotometer. Ultraviolet spectra were recorded with a Hitachi 150-20 spectrophotometer. ^{1}H n.m.r. spectra were recorded at 200 MHz with a Bruker AC-200 spectrometer, or at 300 MHz with a Bruker AM-300 instrument. ^{13}C n.m.r. spectra were recorded at 50·3 MHz or at 75·5 MHz respectively with the above instruments. Chemical shifts (δ) are measured in ppm downfield from $SiMe_4$. Mass spectra and accurate mass measurements were made at 70 eV with a V.G. Micromass 7070F spectrometer. Only the molecular ion (if observed) and principal peaks with intensities >10% are reported. Column chromatography was performed with basic alumina, Brockman activity II. Thin-layer chromatography was performed by using Polygram silica gel/UV_{254} precoated plastic sheets (0·20 mm) with fluorescent indicator UV_{254} (Merck). Light petroleum refers to the fraction of boiling point 60–70°.

(a) 1-Bromocyclohexanecarbonyl Chloride (7a)

Thionyl chloride (11 ml, 0·15 mol) was added dropwise to cyclohexanecarboxylic acid (15·62 g, 0·12 mol), and the mixture was heated at 90° for 2 h, then allowed to cool until the internal temperature had dropped below 80°. Red phosphorus (0·19 g, 6 mmol) was added and the mixture was again heated until the internal temperature had reached 90°. Bromine (9·5 ml, 0·18 mol) was then added at such a rate that the internal temperature remained below 105°. The mixture was heated at 100° for 80 min then cooled and poured quickly into a solution of sodium hydroxide (6·0 g, 0·15 mol) in ice-water (100 ml). The product was extracted with dichloromethane, and the extract was washed successively with 1 M sodium metabisulfite, saturated aqueous sodium hydrogen carbonate, then brine. Evaporation of the dried ($MgSO_4$) extract gave a brown oil (26·08 g, 95%), distillation of which afforded pure bromo acyl chloride (7a), b.p. 121–124°/21 mm (lit.[7] 129–131°/29 mm). ν_{max} (film) 1780 cm^{-1}. ^{1}H n.m.r. δ ($CDCl_3$) 1·43–1·86, m, 6H; 2·19–2·24, m, 4H. ^{13}C n.m.r. δ ($CDCl_3$) 23·6, C3,5 or C4; 24·6, C4 or C3,5; 38·8, C2,6; 72·6, C1; 170·4, CO.

Acidification of the aqueous phase, then extraction with ether gave cyclohexanecarboxylic acid (0·76 g, 4%), identified by its ^{1}H n.m.r. spectrum.

(b) 1-Bromo-N-methyl-N-phenylcyclohexanecarboxamide (7b)

A solution of the acyl chloride (7a) (30·0 g, 0·13 mol) in benzene (14 ml) was added dropwise to a stirred solution of *N*-methylaniline (15 ml, 0·14 mol) and triethylamine (78 ml, 0·56 mol) in benzene (25 ml) kept at 0°. The mixture was stirred at 0° for 60 min, then heated at reflux for 100 min. The cooled mixture was extracted with benzene, and the extract was washed successively with 2 M hydrochloric acid, 5% sodium hydrogen carbonate solution, then brine. Evaporation of the dried (Na_2SO_4) extract gave the *amide* (7b) as a brown oil (32·18 g, 82%) (Found: $M^{+\bullet}$, 295·059±0·003. $C_{14}H_{18}BrNO$ requires $M^{+\bullet}$, 295·057). ν_{max} (film) 1645 cm^{-1}. ^{1}H n.m.r. δ ($CDCl_3$) 1·33–1·61, m, 6H; 1·81–1·97, m, 4H; 3·34, s, NMe; 7·33–7·43, m, 5 aromatic H. ^{13}C n.m.r. δ ($CDCl_3$) 24·2, C3,5 or C4; 24·9, C4 or C3,5; 39·6, C2,6; 42·2, NMe; 65·5, C1; 128·1, C4′; 128·2, C2′,6′ or C3′,5′; 129·3, C3′,5′ or C2′,6′; 144·5, C1′; 169·7, CO. Mass spectrum: *m/z* 297 (M, ^{81}Br, 7%), 295 (M, ^{79}Br, 7), 216 (39), 215 (64), 160 (100), 147 (17), 134 (31), 130 (17), 109 (21), 108 (18), 106 (20), 105 (20), 81 (44), 79 (17), 77 (24).

Attempted distillation (oven temperature 119°/0·125 mm) resulted in elimination of hydrogen bromide to give the unsaturated amide (8) (see below).

(c) N-Methyl-N-phenylcyclohex-1-ene-1-carboxamide (8)

The bromo amide (7b) (14·88 g, 0·05 mol) was added to dry quinoline (10·4 ml, 0·09 mol), and the solution was stirred under nitrogen at 120° for 2 h. The cooled mixture was acidified with 2 M hydrochloric acid (60 ml), and the product was extracted with ether. The extract was washed successively with 1 M hydrochloric acid, saturated aqueous sodium hydrogen car-

bonate, then brine. Evaporation of the dried ($MgSO_4$) extract gave the unsaturated amide (8) (10·00 g, 92%) as a yellow oil, b.p. 123–124°/0·2 mm. ν_{max} (film) 1656, 1635 cm^{-1}. ^1H n.m.r. δ ($CDCl_3$) 1·29–1·52, m, 4H; 1·80–2·00, m, 4H; 3·34, s, NMe; 5·78–5·86, m, H 2; 7·07–7·38, m, 5 aromatic H. ^{13}C n.m.r. δ ($CDCl_3$) 21·2, C 4 or C 5; 21·8, C 5 or C 4; 24·7, C 3 or C 6; 25·8, C 6 or C 3; 37·4, NMe; 126·2, C 2′,6′; 126·3, C 4′; 128·8, C 3′,5′; 132·3, C 2; 134·4, C 1; 144·8, C 1′; 172·4, CO. The ^1H n.m.r. data were consistent with the values previously reported.[8]

(d) 1-(Trimethoxymethyl)cyclohexene (11)

A solution of the α,β-unsaturated amide (8) (3·18 g, 14·8 mmol) and methyl trifluoromethanesulfonate (1·9 ml, 17·3 mmol) in dichloromethane (6·5 ml) was stirred for 14 h under nitrogen. Ether (30 ml) was added and the solution was cooled to 0°. The white precipitate was collected, washed with ether (25 ml) then dried briefly under vacuum to give the alkoxymethylene iminium salt (9) (4·31 g, 77%). ^1H n.m.r. δ ($CDCl_3$) 1·32–1·53, m, 4H; 1·90–2·08, m, 4H; 3·71, s, OMe; 4·34, s, NMe; 6·45–6·56, m, H 2; 7·35–7·52, m, 5 aromatic H. This salt was dissolved in dichloromethane (6·5 ml), and the solution was added dropwise to a cooled (0°) solution of sodium methoxide (from sodium (0·70 g, 30·4 mmol)) in methanol (10 ml). The mixture was stirred at 0° for 30 min, then the solvents were removed in vacuum and light petroleum (55 ml) was added. The resulting precipitate was removed by filtration and the filtrate was evaporated to give a mixture of the amide acetal (12), the ortho ester (11) and *N*-methylaniline. This mixture was dissolved in methanol (11 ml), then glacial acetic acid (1·1 ml, 19·2 mmol) was added and the solution was stirred for 10 min at room temperature. Potassium carbonate (2·25 g, 16·3 mmol) was added and the methanol was removed in vacuum. After addition of water the mixture was extracted with ether, and evaporation of the dried (K_2CO_3) extract gave a yellow liquid (3·02 g). The ^1H n.m.r. spectrum of this showed it to be essentially a mixture of the ortho ester (11), methyl cyclohex-1-ene-1-carboxylate (15) and *N*-methylaniline. Chromatography over basic alumina (1% ether/light petroleum) gave a 1:3·5 mixture of the methyl ester (15) and *N*-methylaniline (1·20 g). Further elution with the same solvent gave an oil which upon bulb-to-bulb distillation (oven temperature 20°/0·15 mm) afforded *1-(trimethoxymethyl)cyclohexene* (11) (1·88 g, 68%) as a colourless liquid (Found: C, 64·2; H, 9·7. $C_{10}H_{18}O_3$ requires C, 64·5; H, 9·7%). ν_{max} (film) 2938s, 2834s, 1438m, 1276s, 1250s, 1184s, 1139m, 1091s, 1049s, 1030s, 993w, 924w, 908w, 851w cm^{-1}. ^1H n.m.r. δ ($CDCl_3$) 1·53–1·70, m, 4H; 1·85–1·97, m, 2H; 2·03–2·18, m, 2H; 3·13, s, $C(OMe)_3$; 6·09–6·16, m, H 2. ^{13}C n.m.r. δ ($CDCl_3$) 22·1, 22·3, 23·3, 24·8, C 3,4,5,6; 48·9, C(**OMe**)$_3$; 114·5, **C**$(OMe)_3$; 129·3, C 2; 131·8, C 1. Mass spectrum: *m/z* 186 (M, <1%), 155 (83), 154 (55), 109 (12), 105 (100), 95 (11), 81 (34), 80 (17), 79 (40), 77 (18), 59 (17), 53 (19).

Subsequent elution with 2% ether/light petroleum gave starting material (8) (0·24 g, 8%).

(e) Reaction of 1-(Trimethoxymethyl)cyclohexene (11) with N-Methylaniline and Sodium Hydride

A mixture (1·23 g) of *N*-methylaniline (4·19 mmol) and the ortho ester (11) (4·19 mmol) was added to a suspension of sodium hydride (2·26 g of an 80% dispersion in oil, 8·70 mmol) in dry tetrahydrofuran (7·5 ml). The mixture was heated under reflux for 80 min; bulb-to-bulb distillation (water pump vacuum) gave a yellow oil (1·00 g), the ^1H and ^{13}C n.m.r. spectra of which showed it to be a 1:1 mixture of *N*,*N*-dimethylaniline [^1H n.m.r. δ ($CDCl_3$) 2·93, s, NMe_2; diagnostic signal used for integration. ^{13}C n.m.r. δ ($CDCl_3$) 40·4, NMe_2; 112·5, C 2,6 or C 4; 116·5, C 4 or C 2,6; 128·9, C 3,5; 150·6, C 1] and methyl cyclohex-1-ene-1-carboxylate (15), an authentic sample of which was prepared as described below.

(f) Methyl Cyclohex-1-ene-1-carboxylate (15)

The procedure used was a modification of that reported by Lange *et al.*[9] Thionyl chloride (17·5 ml, 0·24 mol) was added dropwise to cyclohexanecarboxylic acid (25·0 g, 0·20 mol), and the mixture was heated at 90° for 24 h. The mixture was allowed to cool until the internal temperature had dropped below 80°, then red phosphorus (0·31 g, 0·01 mol) was added. Heating was reapplied, and, when the internal temperature had reached 90°, bromine (15 ml, 0·29 mol) was added dropwise at such a rate that the internal temperature remained below 105°. The mixture was heated at 100° for 80 min and then cooled to 5°. Methanol (40 ml, 0·99 mol) was added slowly so that the internal temperature remained below 25°, then the mixture was heated at reflux for 15 min, cooled, and poured into ice-water (100 ml). The two-phase system was extracted with ether; the extract was washed successively with 1 M sodium metabisulfite, saturated sodium hydrogen carbonate solution, and brine. The extract was dried ($MgSO_4$) and evaporated to give methyl 1-bromocyclohexanecarboxylate (7c) as a brown oil (39·77 g, 92%). ^1H n.m.r. δ ($CDCl_3$) 1·31–1·61, m, 4H; 1·67–1·84, m, 2H; 2·07–2·25, m, 4H; 3·80, s, OMe. The ^1H n.m.r. data were in agreement with the values previously reported.[9]

Dry quinoline (34 ml, 0·29 mol) was added to the crude bromo ester (7c) (39·77 g), and the solution was heated at 120° under nitrogen for 2 h. The mixture was cooled to room temperature, then treated with 2 M hydrochloric acid (200 ml), and the product was extracted with ether. The extract was washed successively with 1 M hydrochloric acid, saturated sodium hydrogen carbonate solution, and brine. Evaporation of the dried ($MgSO_4$) extract and distillation gave the ester (15) (18·74 g, 68%), b.p. 93–96°/11 mm (lit.[10] 193·5–195·5°). ν_{max} (film) 1715 cm^{-1}. ^1H n.m.r. δ ($CDCl_3$) 1·58–1·67, m, 4H; 2·15–2·28, m, 4H; 3·73, s, OMe; 6·94–7·02, m, H 2. ^{13}C n.m.r. δ ($CDCl_3$) 21·3, 21·9, 24·0, 25·6, C 3,4,5 and C 6; 51·3, OMe; 130·0, C 1; 139·6, C 2; 167·8 O**C**OMe. The ^1H n.m.r. data were in agreement with those previously reported by Krabbenhoft.[11]

(g) Reaction of 1-(Trimethoxymethyl)cyclohexene (11) with 3-Methoxyphenol

(i) *In the presence of* N*-methylaniline and pivalic acid.* A mixture (1·00 g) consisting of *N*-methylaniline (3·41 mmol) and the ortho ester (11) (3·41 mmol) was dissolved in benzene (5 ml), and the solvent was distilled off at atmospheric pressure. The residue was dissolved in toluene (5 ml), then 3-methoxyphenol (0·4 ml, 3·65 mmol) and pivalic acid* (0·52 g, 5·10 mmol) were added, and the mixture was heated at reflux under nitrogen for 20 h. The cooled mixture was extracted with ether (20 ml), and the extract was washed with 5% sodium hydroxide solution, then with water. Evaporation of the dried (K_2CO_3) extract gave a yellow oil (0·75 g) which was shown by its ^1H n.m.r. spectrum to be a mixture of methyl cyclohex-1-ene-1-carboxylate (15) and *N*-methyl-*N*-phenylcyclohex-1-ene-1-carboxamide (8) in the ratio 1:3·5, together with small amounts of *N*,*N*-dimethylaniline and methyl pivalate.

(ii) *In the presence of a catalytic amount of pivalic acid.* A mixture (0·30 g) consisting of *N*-methylaniline (0·07 mmol) and the ortho ester (11) (1·57 mmol) was dissolved in toluene (4 ml), and then half of the solvent was distilled off at atmospheric pressure. Likewise, 3-methoxyphenol (0·20 ml, 1·82 mmol) and pivalic acid (0·08 g, 0·78 mmol) were dissolved in toluene (4 ml), and half of the solvent was distilled off. The cooled

* 2,2-Dimethylpropanoic acid.

concentrates from both distillations were combined and the mixture was distilled slowly under nitrogen for 2 h after which time 1 ml of distillate had been collected. Workup as in (i) gave a yellow oil (0·27 g), the ^{1}H n.m.r. spectrum of which showed it to contain the ortho ester (11), the methyl ester (15), the amide (8) and the mixed ortho ester (10) (see (iv)), present in the ratio 4 : 13 : 1 : 6·5, respectively. A small amount of methyl pivalate was also detected.

(iii) *In the presence of methanesulfonic acid.* 3-Methoxyphenol (0·17 ml, 1·50 mmol) was dissolved in toluene (8 ml), and half of the solvent was distilled off at atmospheric pressure. Likewise, a mixture (0·25 g) containing *N*-methylaniline (0·10 mmol) and the ortho ester (11) (1·27 mmol) was dissolved in toluene (6 ml), and 1 ml of the solvent was distilled off. The second solution was cooled to room temperature, then methanesulfonic acid (40 μl, 0·62 mmol) and an aliquot (1 ml) of the 3-methoxyphenol solution, prepared above, were added and the mixture was heated at reflux under nitrogen. The remainder of the 3-methoxyphenol solution was added in three equal portions at hourly intervals and then the mixture was heated under reflux for 1 h. Workup as in (i) gave a colourless oil (0·22 g), the ^{1}H n.m.r. spectrum of which showed it to contain starting material (11), the methyl ester (15), the amide (8) and the mixed ortho ester (10), present in the ratio 1 : 7·5 : 1 : 4·5 respectively. Methyl methanesulfonate was also detected in the crude product.

(iv) *In the absence of acid.* The previous reaction was repeated on the same scale, but the methanesulfonic acid was omitted. The usual workup gave a colourless oil (0·30 g). The ^{1}H n.m.r. spectrum showed this to contain starting material (11) and the mixed ortho ester (10), in the ratio 1 : 1·7 respectively, together with a small amount of *N*-methylaniline. This oil was dissolved in toluene (10 ml), 3-methoxyphenol (60 μl, 0·55 mmol) was added and half of the solvent was distilled off at atmospheric pressure during 2·5 h. Workup, as before, gave a yellow oil (0·30 g), the ^{1}H n.m.r. spectrum of which showed it to be essentially a 1 : 4 mixture of starting material (11) and the mixed ortho ester (10). Subtraction of the signals for the starting material (11) gave the following spectroscopic data for the mixed ortho ester* (10). ^{1}H n.m.r. δ ($CDCl_3$) 1·42–1·65, m, 4H; 1·85–1·98, m, 2H; 2·02–2·18, m, 2H; 3·24, s, $C(OMe)_2$; 3·76, s, 3′-OMe; 6·25–6·36, m, H 2; 6·53, dd, *J* 8·2, 1·3 Hz, H4′ or H 6′; 6·70–6·80, m, H 2 and (H 6′ or H 4′); 7·11, t, *J* 8·3 Hz, H 5′. ^{13}C n.m.r. δ ($CDCl_3$) 22·0, 22·3, 23·4, 24·9, C 3,4,5 and C 6; 49·4, $C(OMe)_2$; 55·2, 3′-OMe; 104·3, C 2′; 107·5, C 4′ or C 6′; 110·7, C 6′ or C 4′; 115·5, $\mathbf{C}(OMe)_2$; 129·2, C 2 or C 5′; 130·4, C 5′ or C 2; 131·9, C 1; 154·8, C 1′; 160·2, C 3′.

Attempts to purify the mixed ortho ester (10) by bulb-to-bulb distillation (150°/3 mm) were accompanied by a small amount of hydrolysis so that the product (10) was contaminated with 3-methoxyphenol and the methyl ester (15). Distillation of (10) at atmospheric pressure (250°) gave a complex mixture which contained 1,3-dimethoxybenzene (16) and the ester (15), formed by thermal degradation (^{1}H n.m.r. spectrum).

Acknowledgments

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* 1-[Dimethoxy(3′-methoxyphenoxy)methyl]cyclohexene.