Notes

Synthesis of Carbocamphenilone and Its 6,7-Dehydro Derivative[1]

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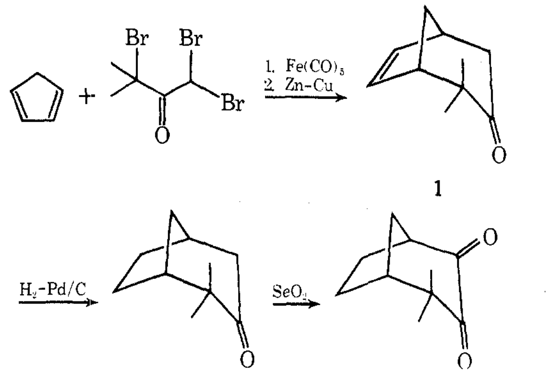
Carbocamphenilone (3) is a terpenic α diketone which has been of interest as a skewed glyoxal model.[2] Previously its syntheses have been achieved from camphene only in low yields and the diketone[3] or its synthetic precursors[4] were usually obtained by isolation from complex reaction mixtures. This note describes an effective, rational route to 3 which is based on the recently developed iron carbonyl promoted cyclocoupling between polybromo ketones and 1,3-dienes.[1,5,6]

Reaction of 1,1,3-tribromo-3-methylbutan-2-one and cyclopentadiene in the presence of iron pentacarbonyl followed by Zn–Cu couple reduction of the reaction mixture gave the bicyclic ketone 1 (83% yield by GLC, 66% yield after isolation). Catalytic hydrogenation of 1 on Pd/C afforded the saturated ketone 2, which was oxidized with selenium dioxide in refluxing xylene to give the desired α diketone 3 quantitatively. Camphenic acid (4) can be obtained readily by potassium permanganate oxidation of 2.[4d,7]

Oxidation of the unsaturated bicyclic ketone 1 with selenium dioxide led to 6,7-dehydrocarbocamphenilone (5) in 72% yield. Notably, for diketone 5 the carbon–carbon double bond and carbonyl moieties are situated such that interaction can occur and hence 5 serves as a new example of a homoconjugated α diketone.[8] As a consequence of the strong homoconjugation in an excited state,[9] 5 exhibits characteristic uv–visible absorptions, in marked contrast with the saturated analog 3; see Figure 1. Diketone 3 shows absorptions due only to n–π^* transitions. The unsaturated ketone 1 does not give an unusual spectrum either [in isooctane, n–π^* band at 295 nm (ϵ 31)] [cf. 2 (isooctane) λ_{max} 298 nm (ϵ 23)]. The spectrum of the unsaturated diketone 5 shows a π–π^* band at 249 nm (ϵ 675) as well as the n–π^* bands which are shifted bathochromically with concomitant hyperchromic effect. Fine structure is observed in the 431-nm band.[9b,c] Interestingly, the C-6 vinylic proton of 5 exhibits a NMR signal at unusually low field, δ 6.54; this value should be compared with that of the C-7 vinylic proton, δ 5.97, as well as the chemical shift of the vinylic protons of the unsaturated monoketone 1, δ 6.12. This deshielding could be explained by the ground-state homoconjugation effect; the conventional resonance description, 5 ↔ 5a, could account for the electron deficiency at the C-6 position.



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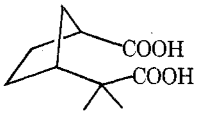

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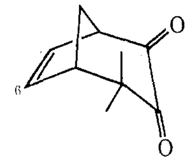

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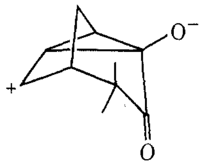

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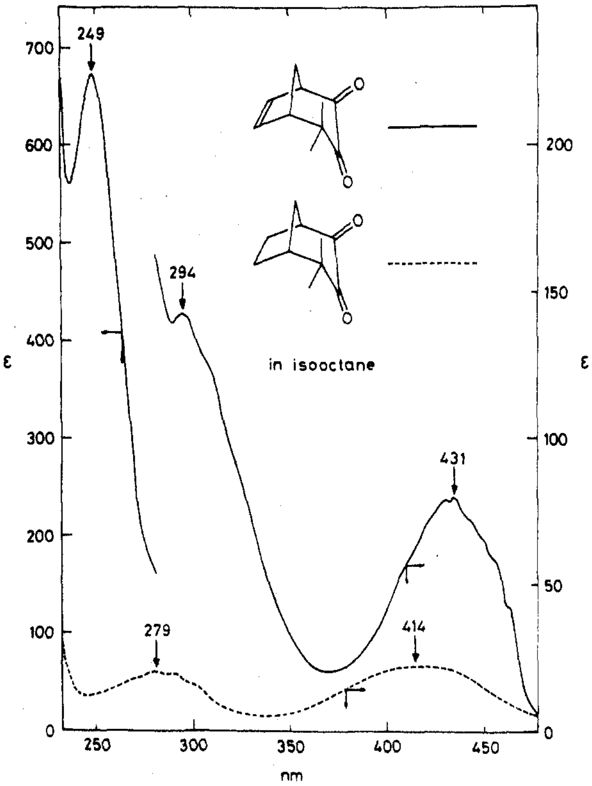

Figure 1. Electronic absorption spectra of carbocamphenilone (3) and the dehydro derivative 5.

Experimental Section

All melting points are uncorrected. Nuclear magnetic resonance (NMR) spectra were recorded on either a Varian HA-100D or JEOLCO C-60H instrument with tetramethylsilane as an internal standard. Infrared (ir) spectra were measured with a Nihon Bunko DS-402G spectrometer, and ultraviolet (uv)–visible spectra with a Hitachi Model 323 instrument. Mass spectra were determined on a Hitachi RMU 6C-2 spectrometer at 70 eV ionizing irradiation. Gas chromatographic analyses (GLC) were performed on a Hitachi 063 gas chromatograph equipped with a column of 5% poly(diethylene glycol succinate) on Neopak 1A (2 m, column temperature 100°). For column chromatography Merck Kieselgel 60 (70–230 mesh) was used.

2,2-Dimethylbicyclo[3.2.1]oct-6-en-3-one (1). To a mixture of freshly distilled cyclopentadiene (1.0 ml), iron pentacarbonyl (Strem, 0.78 ml, 1.17 g, 5.98 mmol), dry tetrahydrofuran (1.0 ml), and dry benzene (10.0 ml) stirring at 80° under argon was added dropwise a solution of 1,1,3-tribromo-3-methylbutan-2-one[10] (1.62 g, 5.00 mmol) in 1:1 cyclopentadiene-benzene (7.5 ml) over 25 min. The resulting mixture was stirred for an additional 45-min period at the same temperature. After cooling, the reaction mixture was quenched by addition of methanol (12.0 ml) saturated with NH_4Cl and shaken vigorously with Zn-Cu couple[11] (3.80 g, 57.8 mg-atoms) for 20 min. The reaction mixture was diluted with methylene chloride (200 ml) and a saturated aqueous solution (100 ml) of ethylenediaminetetraacetic acid disodium salt. The insoluble materials were removed by filtration, and the filtrate was extracted twice with methylene chloride (50 and 30 ml). The combined organic layers were dried over sodium sulfate and concentrated to give an oily residue (2.16 g), whose GLC analysis showed the yield of the desired adduct 1 (retention time 8 min) to be 83%. The oil was dissolved in methylene chloride (20 ml) and added dropwise to vigorously stirred *n*-hexane (200 ml). The resulting insoluble precipitates were removed by filtration and the filter cake was washed thoroughly with *n*-hexane. The filtrate and washing were combined and evaporated to leave an oil (1.10 g), which was chromatographed on a silica gel column (15 mm diameter, 15.0 g). Elution with 1:1 benzene–*n*-hexane (110 ml) and 1:10 ethyl acetate–*n*-hexane (50 ml) and collecting 10-ml fractions gave an oily 1 (95% pure by NMR analysis, 520 mg, 66% yield) in fractions 9–15, which was identified by comparison of the NMR spectrum with the reported one.[12] Bulb-to-bulb distillation of this oil gave an analytical sample (375 mg), bp 70–120° (bath temperature) (2 mm), as colorless crystals, mp 45–48° (lit.[12] an oil).

2,2-Dimethylbicyclo[3.2.1]octan-3-one (2). Cycloadduct 1 (300 mg, 2.00 mmol) was stirred in ethyl acetate (5.0 ml) containing 10% Pd/C (30 mg) under atmospheric pressure of hydrogen at room temperature for 3 hr. The catalyst was removed by filtration and the filtrate was concentrated to give an oil (350 mg). Bulb-to-bulb distillation of the oil gave **2** (242 mg, 80% yield) as colorless crystals, bp 80–130° (bath temperature) (2 mm), mp 35–37° (lit.[3d] an oil), showing an NMR spectrum identical with the reported one.[3d] Its 2,4-dinitrophenylhydrazone melted at 117–118° (lit.[3d] mp 117.5–119.5°).

Carbocamphenilone (3). Selenium dioxide (90 mg, 0.81 mmol) and **2** (61 mg, 0.40 mmol) were mixed in dry xylene (1.2 ml) and the slurry was heated at 140° with stirring. After 4 hr the reaction mixture was subjected directly to column chromatography (8 mm diameter) on silica gel (2.0 g). The column was eluted with *n*-hexane followed by benzene. After concentration the fraction eluted with benzene yielded carbocamphenilone (**3**) (79 mg, quantitative yield) as yellow crystals. On recrystallization from *n*-pentane an analytical sample was obtained, mp 57–61° (lit. mp 49–52°,[2a] 59–60°,[2f] 50–53°,[3d] 58–59°,[4a] 56–59°,[4b] and 48–50° [4d]). Its ir and NMR spectra were identical with reported ones.[4d]

4,4-Dimethylbicyclo[3.2.1]oct-6-ene-2,3-dione (6,7-Dehydrocarbocamphenilone) (5). A mixture of **1** (136 mg, 0.90 mmol) and selenium dioxide (200 mg, 1.80 mmol) in dry xylene (2.5 ml) was stirred at 140° for 4 hr. The resulting mixture was chromatographed on a silica gel column (8 mm diameter, 4.0 g) with *n*-hexane (20 ml), benzene (75 ml), and 1:10 ethyl acetate–benzene (50 ml) and 5-ml fractions were collected. Fractions 14–21 gave a yellow, crystalline **5** (106 mg, 72% yield), which was recrystallized from *n*-pentane to afford an analytical specimen: mp 57–61°; ir (CCl_4) 1736 (weak) and 1720 cm^{-1} (C=O); uv–visible max (isooctane) 249 nm (ϵ 675), 294 (141), and 431 (77.7); NMR (CCl_4) δ 1.14 and 1.24 (s, 3 H each, CH_3), 2.40 (m, 2 H, CH_2), 2.58 [m, 1 H, $(CH_3)_2CC\mathbf{H}$], 3.42 (m, 1 H, COCH), 5.97 (dd, 1 H, J = 2.3 and 6.0 Hz, $(CH_3)_2CCHC\mathbf{H}=$), and 6.54 (dd, 1 H, J = 2.3 and 6.0 Hz, $COCHC\mathbf{H}=$). The assignment of NMR signals was confirmed by double-resonance technique; irradiation at δ 3.42 changed the δ 5.97 signal into a doublet with J = 6.0 Hz, and irradiation at δ 2.58 gave a doublet with J = 6.0 Hz at δ 6.54.

Anal. Calcd for $C_{10}H_{12}O_2$: C, 73.14; H, 7.37. Found: C, 73.11; H, 7.37.

Registry No.—**1,** 22940-29-0; **2,** 55682-09-2; **3,** 27455-93-2; **5,** 55682-10-5; cyclopentadiene, 542-92-7; 1,1,3-tribromo-3-methylbutan-2-one, 1578-05-8.

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Regioselectivity in the Reaction of $C_5H_5Fe(CO)_2(isobutylene)^+BF_4^-$ with Polyenes

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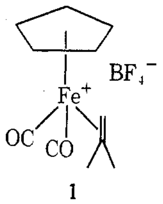
The recently demonstrated abilities of the $C_5H_5Fe(CO)_2^+$(Fp^+) group to activate olefins toward nucleophilic attack[1] and to stabilize highly reactive alkenes (e.g., cyclobutadiene[2] and benzocyclobutadiene[3]) promise to be of considerable synthetic value. In connection with our evaluation of this organometallic moiety as a protecting group for the carbon–carbon double bond,[4] we have investigated the regioselectivity for the metalation of unsymmetrical polyenes with Fp(isobutylene)$^+BF_4^-$ (**1**).[5]

When 1,2-dichloroethane solutions of **1** were heated (65–70°, 10 min) in the presence of a tenfold excess of the



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polyenes 4-vinylcyclohexene (**2**), *trans*-piperylene (**3**), 2-methyl-1,5-hexadiene (**4**), 1-octen-4-yne (**5**), *endo*-dicyclopentadiene (**6**), 1,3,6-heptatriene (**7**), and 5-vinyl-2-norbornene (**8**), 1:1 complexes formed as air-stable yellow solids in good yield.[6] The structures of the complexes **9**–**15** followed readily from their ^1H NMR spectra (Table I) since olefinic proton absorptions are generally shielded ca. 1.0–1.7 ppm upon coordination by Fp^+ whereas allylic proton absorptions are correspondingly deshielded ca. 0.4 ppm. For each substrate (except **8**) only one positionally isomeric complex was detectable by NMR, indicating at least 90–95% regioselectivity. Additional support for the assigned structures was obtained by comparison of ^1H NMR spectra with model systems or by hydrogenation of the free unsaturation and comparison of the resulting complexes with authentic samples.[7]