

Synthesis and Some Reactions of 3-(Phenyl-*o*-carboranyl)indan-1-one

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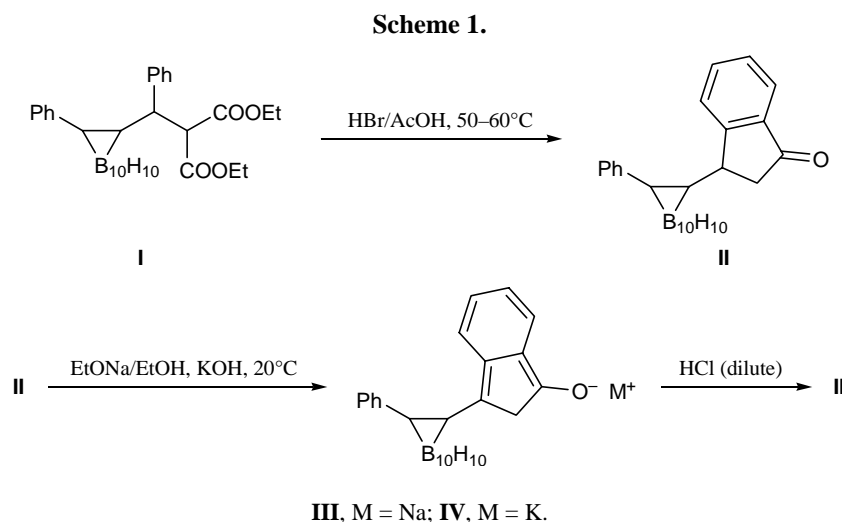
Abstract—3-(Phenyl-*o*-carboranyl)indan-1-one was synthesized, and its reactions with sodium ethoxide, potassium hydroxide, and primary and secondary amines in various media were studied. Preparative procedures for the synthesis of a series of previously unknown *o*-carborane derivatives were thus developed.

We previously showed that [1] that diethyl α -(*R*-*o*-carboranyl)benzylmalonates, which are formed in high yield by the action of lithiated *o*-carboranes on diethyl benzylidenemalonate, react with a mixture of hydrochloric and acetic acids on heating to give β -(*R*-*o*-carboranyl)- β -phenylpropionic acids. In the present work we examined the reaction of diethyl α -(phenyl-*o*-carboranyl)benzylmalonate (**I**) with a mixture of acetic and hydrobromic acids under various conditions.

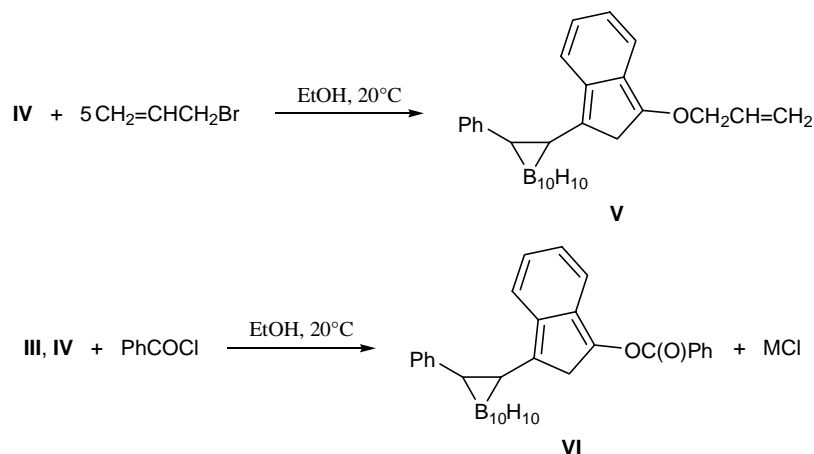
We have found that ester **I** reacts with HBr–AcOH at 50–60°C in a regioselective fashion, quantitatively yielding 3-(phenyl-*o*-carboranyl)indan-1-one (**II**) (Scheme 1). While extending these studies, we examined reactions of compound **II** with sodium ethoxide in ethanol, with potassium hydroxide in diethyl ether and ethanol, and with primary and secondary amines in various media. Substituted indanone **II**

turned out to behave differently from its unsubstituted analog. By the action of sodium ethoxide in ethanol or potassium hydroxide in ethanol or ether on compound **II** we obtained, respectively, sodium and potassium enolates **III** and **IV** in quantitative yield. Salts **III** and **IV** are stable readily crystallizable substances. Treatment of **III** and **IV** with dilute hydrochloric acid quantitatively recovers indanone **II** (Scheme 1).

Enolates **III** and **IV** were brought into halogenation with bromine, alkylation with methyl iodide and allyl bromide, and acylation with benzoyl chloride. The results showed that compounds **III** and **IV** failed to react with Br₂, MeI, and CH₂=CHCH₂Br under standard conditions [molar reactant ratio 1:(1–3)]. No expected C-bromination or C-alkylation products were obtained. However, the reaction of potassium enolate **IV** with 5 equiv of allyl bromide in ethanol afforded



Scheme 2.



M = Na, K.

~ 50% of *O*-allyl ether **V** (Scheme 2). Salts **III** and **IV** readily reacted with benzoyl chloride to give benzoate **VI**. It remains unclear why enolates **III** and **IV** behave differently in reactions with allyl bromide at reactant ratios of 1:(1–3) and 1:5. Presumably, specific chemical reactivity of compounds **III** and **IV** is explained by the effect of electron-acceptor carboranyl substituent which is capable of deactivating the adjacent double bond toward electrophilic addition.

From the theoretical and preparative viewpoints, it was interesting to examine reactions of indanone **II** with amines. It is known that reactions of amines with carborane derivatives usually lead to cleavage of the carborane skeleton and formation of decarbundecaborate adducts. No expected Schiff base was obtained from indanone **II** and aniline under standard conditions. On the other hand, compound **II** relatively readily reacted with benzylamine and methylamine, yielding the corresponding Schiff bases **VII** and **VIII** (Scheme 3). Reactions of **II** with equimolar amounts of morpholine and piperidine in a benzene–diethyl ether mixture, as well as with dimethylamine in aqueous medium, occurred only at the CH group to

afford ammonium salts **IX–XI**. Treatment of the latter with gaseous hydrogen chloride leads to quantitative formation of initial indanone **II** (Scheme 3).

The reaction of **II** with 2 equiv of morpholine gave morpholinium salt **XII**, presumably according to Scheme 4. Cytisine failed to react with indanone **II** in benzene–diethyl ether, presumably due to steric effect of the carboranyl group.

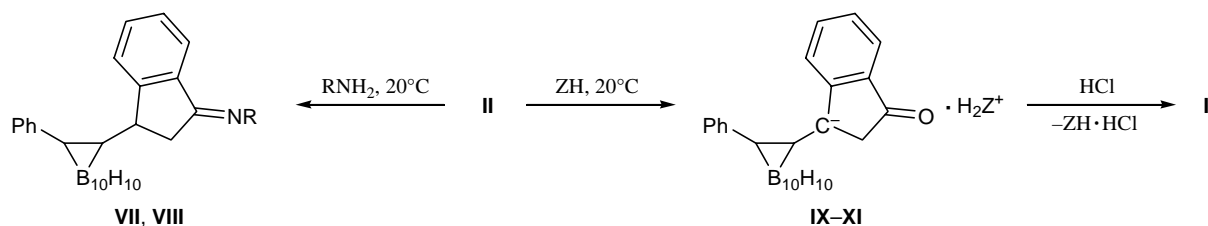
The structure of compounds **II–XII** was confirmed by the data of elemental analysis and IR and ¹H NMR spectroscopy, as well as by their chemical transformations.

EXPERIMENTAL

The IR spectra were recorded in KBr on a UR-20 spectrometer. The ¹H NMR spectra were obtained on a Bruker DRX-500 instrument (500,13 MHz) using CDCl₃ or CD₃OD as solvent and TMS as internal reference.

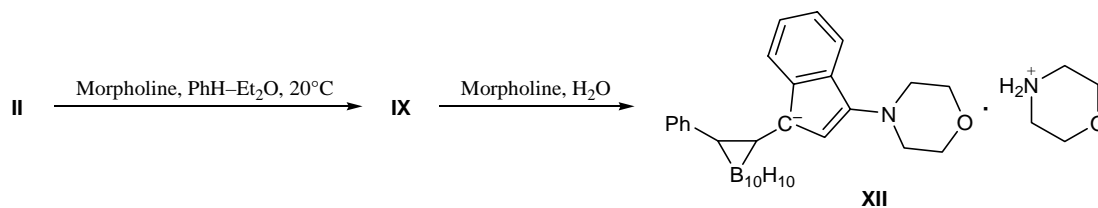
3-(Phenyl-*o*-carboranyl)indan-1-one (II). To 4.68 g (10 mmol) of ester **I** we added 17 ml of 48% hydrobromic acid and 51 ml of acetic acid, and the

Scheme 3.



VII, R = PhCH₂; **VIII**, R = Me; **IX**, ZH = morpholine; **X**, ZH = piperidine; **XI**, ZH = Me₂NH.

Scheme 4.



mixture was heated for 48 h at 50–60°C. It was then cooled, and the precipitate was filtered off, washed with hexane, and dried in a vacuum desiccator over KOH. The filtrate was treated with Na₂CO₃ and extracted with benzene. The extracts were dried over Na₂SO₄ and evaporated, and the residue was recrystallized from hexane. The portions of the product were combined. Overall yield 3.43 g (98%), mp 113–114°C (from benzene–hexane, 1:5). IR spectrum, ν , cm⁻¹: 3060, 3020 (C–H); 2580 (B–H); 1710 (C=O); 1420, 1150, 745 (C₆H₅). ¹H NMR spectrum (CDCl₃), δ , ppm: 2.88 d.d (2H, CH₂, J = 3.1 Hz), 3.28 d.d (1H, CH, J = 2.8 Hz), 7.1–7.7 m (9H, H_{arom}, J = 2.4 Hz), 1.4–3.1 m (10H, BH, J = 10 Hz). Found, %: C 58.60; H 6.13; B 31.35. C₁₇H₂₂B₁₀O. Calculated, %: C 58.28; H 6.28; B 30.86.

Reactions of 3-(phenyl-*o*-carboranyl)indan-1-one (II) with EtONa and KOH. *a.* A solution of 1.1 mmol of EtONa in 5 ml of ethanol was added at 20°C to a solution of 0.35 g (1 mmol) of indanone II in 10 ml of ethanol, and the mixture was stirred for 2 h at 20°C. The solvent was removed, and the residue was recrystallized from hexane. Yield 0.35 g (94%) of sodium salt III, mp 328°C (decomp.). IR spectrum, ν , cm⁻¹: 2580 (B–H); 1560 (C=C); 1140, 680 (C₆H₅). Found, %: C 55.28; H 5.96. C₁₇H₂₁B₁₀NaO. Calculated, %: C 54.84; H 5.64.

b. Powdered KOH, 0.06 g (1.1 mmol), was added at 20°C to a solution of 0.35 g (1 mmol) of indanone II in 10 ml of ethanol or diethyl ether, and the mixture was stirred for 2 h at 20°C. The solvent was removed, and the residue was recrystallized from hexane. Yield 0.38 g (97%) of potassium salt IV, mp 275°C (decomp.). IR spectrum, ν , cm⁻¹: 2580 (B–H); 1560 (C=C); 1130, 720, 690 (C₆H₅). Found, %: C 52.43; H 5.18. C₁₇H₂₁B₁₀KO. Calculated, %: C 52.57; H 5.41.

c. Salt III or IV, 5 mmol, was dissolved in 10 ml of ethanol, and the solution was treated with dilute hydrochloric acid until acidic reaction and was then extracted with benzene. The extract was dried over Na₂SO₄ and evaporated, and the residue was recrystallized from hexane. The yield of indanone II was 95% from III and 92% from IV, mp 113–114°C.

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1-Allyloxy-3-(phenyl-*o*-carboranyl)-2H-indene (V). Powdered potassium hydroxide, 0.3 g (5.2 mmol), was added to a solution of 1.75 g (5 mmol) of indanone II in 10 ml of ethanol. The mixture was stirred for 1.5 h at 20°C, and 3 g (25 mmol) of allyl bromide was added. After 24 h, the mixture was treated with distilled water and extracted with benzene. The extract was dried over Na₂SO₄ and evaporated, and the residue was recrystallized from hexane. Yield 0.94 g (48%), mp 218–219°C (from THF–hexane, 1:6). IR spectrum, ν , cm⁻¹: 2580 (B–H), 1530 (C=C); 1080, 1040, 1010 (=C–O–C); 1625, 990, 970, 920 (CH₂CH=CH₂). Found, %: C 61.92; H 6.24; B 28.04. C₂₀H₂₆B₁₀O. Calculated, %: C 61.54; H 6.67; B 27.69.

3-(Phenyl-*o*-carboranyl)-2H-inden-1-yl benzoate (VI). Powdered KOH, 0.3 g (5.2 mmol), was added to a solution of 1.75 g (5 mmol) of indanone II in 10 ml of ethanol. The mixture was stirred for 1.5 h at 20°C, and 0.78 g (5.1 mmol) of benzoyl chloride was added. After 5 h, the precipitate was filtered off, and the filtrate was evaporated. Yield 1.5 g (66%), mp 142.5–143°C (from benzene–hexane, 1:5). IR spectrum, ν , cm⁻¹: 2580 (B–H); 1615, 1530, 1210, 1130 (=C–O–COPh). Found, %: C 63.95; H 5.12; B 24.15. C₂₄H₂₆B₁₀O₂. Calculated, %: C 63.44; H 5.73; B 23.79.

***N*-Benzyl-3-(phenyl-*o*-carboranyl)indan-1-imine (VII).** Benzylamine, 0.55 g (5.1 mmol), was added at 20°C to a solution of 1.75 g (5 mmol) of indanone II in 10 ml of a benzene–diethyl ether mixture. The resulting mixture was stirred for 6 h at 20°C, and the precipitate was filtered off and recrystallized from THF–hexane (1:6). Yield 2.06 g (94%), mp 184–185°C. IR spectrum, ν , cm⁻¹: 2580 (B–H); 1600 (C=N); 1520, 1470 (C₆H₅). ¹H NMR spectrum (CD₃OD), δ , ppm: 2.82 d.d. (2H, CH₂, J_1 = 2.4, J_2 = 3.8 Hz), 3.58 d.d (1H, CH, J_1 = 2.4, J_2 = 3.8 Hz), 4.04 s (2H, PhCH₂N=, J = 3.2 Hz), 7.1–7.8 m (14H, H_{arom}, J = 3.8 Hz), 1.4–3.1 m (10H, BH, J = 10 Hz). Found, %: C 65.31; H 7.08; B 25.03; N 3.58.

$C_{24}H_{29}B_{10}N$. Calculated, %: C 65.60; H 6.61; B 24.60; N 3.19.

***N*-Methyl-3-(phenyl-*o*-carboranyl)indan-1-imine (VIII).** A 25% solution of methylamine, 1 ml (5.2 mmol), was added at 20°C to a solution of 1.75 g (5 mmol) of indanone **II** in 10 ml of ethanol, and the mixture was stirred for 6 h at 20°C. The solvent was removed, and the residue was recrystallized from hexane. Yield 1.65 g (91%), mp 186–187°C (from THF–hexane, 1:6). IR spectrum, ν , cm^{-1} : 2580 (B–H); 1620 (C=N); 1540, 1480, 690 (C_6H_5). Found, %: C 59.92; H 7.03; B 29.12; N 4.13. $C_{18}H_{25}B_{10}N$. Calculated, %: C 59.50; H 6.89; B 29.75; N 3.86.

Reaction of 3-(phenyl-*o*-carboranyl)indan-1-one (II) with morpholine. Morpholine, 0.45 g (5.1 mmol), was added at 20°C to a solution of 1.75 g (5 mmol) of indanone **II** in 10 ml of benzene–diethyl ether. The mixture was stirred for 5 h, treated with an aqueous solution of ammonium chloride, and extracted with benzene. The extract was dried over Na_2SO_4 and evaporated, and the residue was recrystallized from hexane. We thus isolated 1.94 g (89%) of morpholinium 1-oxo-3-(phenyl-*o*-carboranyl)indan-3-ide (**IX**), mp 180.5–181.5°C (from THF–hexane, 1:6). IR spectrum, ν , cm^{-1} : 2580 (B–H); 1700 (C=O); 1600, 1170, 750 (C_6H_5). 1H NMR spectrum (CD_3OD), δ , ppm: 2.83 d.d (2H, CH_2 , $J = 4.4$ Hz), 2.96 t (4H, CH_2N , $J = 2.0$ Hz), 3.68 t (4H, CH_2O , $J = 2.0$ Hz), 3.34 s (1H, NH), 3.55 d.d (1H, CH, $J_1 = 2.2$, $J_2 = 4.2$, $J_3 = 2.2$ Hz), 7.1–7.8 m (9H, H_{arom} , $J = 5.0$ Hz), 1.6–3.0 m (10H, BH, $J = 10$ Hz). Found, %: C 58.12; H 6.54; B 24.96; N 3.58. $C_{21}H_{31}B_{10}NO_2$. Calculated, %: C 57.67; H 7.09; B 24.71; N 3.20.

Piperidinium 1-oxo-3-(phenyl-*o*-carboranyl)indan-3-ide (X) was synthesized in a similar way from

5 mmol of compound **II** and 5.1 mmol of piperidine. Yield 82%, mp 174–175°C (from benzene–hexane, 1:5). IR spectrum, ν , cm^{-1} : 2500–2480, 1600 ($^+NH_2$); 2580 (B–H); 1700 (C=O). Found, %: C 61.05; H 7.13; B 25.31; N 3.64. $C_{22}H_{33}B_{10}NO$. Calculated, %: C 60.69; H 7.59; B 24.83; N 3.32.

Dimethylammonium 1-oxo-3-(phenyl-*o*-carboranyl)indan-3-ide (XI) was synthesized in a similar way from 5 mmol of compound **II** and 5.1 mmol of dimethylamine. Yield 90%, mp 211–213°C (from THF–hexane, 1:6). IR spectrum, ν , cm^{-1} : 2700, 2630, 2490–2330, 1605 ($^+NH_2$); 2570 (B–H); 1690 (C=O); 1560, 1115, 750 (C_6H_5). Found, %: C 57.45; H 6.94; B 27.68; N 3.12. $C_{19}H_{29}B_{10}NO$. Calculated, %: C 57.72; H 7.34; B 27.34; N 3.54.

Morpholinium 3-morpholino-1-(phenyl-*o*-carboranyl)inden-1-ide (XII). Morpholine, 0.45 g (5.1 mmol), was added at 20°C to a solution of 1.75 g (5 mmol) of indanone **II** in 10 ml of benzene–diethyl ether. The mixture was stirred for 5 h at that temperature, 0.45 g (5.1 mmol) of morpholine was added, and the mixture was vigorously stirred for 6 h at 20°C. The precipitate was filtered off and recrystallized from THF–hexane (1:6). Yield 1.87 g (74%), mp 191–192°C. IR spectrum, ν , cm^{-1} : 2670, 2650, 2630, 2570, 2540, 1550 ($^+NH_2$); 2600 (B–H); 1630 (C=C); 1145, 700 (C_6H_5). Found, %: C 59.92; H 6.83; B 21.84; N 5.02. $C_{25}H_{37}B_{10}N_2O_2$. Calculated, %: C 59.41; H 7.33; B 21.39; N 5.54.

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