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Reactions of Lithium Derivatives of *o*- and *m*-Carboranes with 5,6-Benzocoumarin and 5,6-Benzo-3-ethoxycarbonylcoumarin

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Abstract—Reactions of lithium derivatives *o*- and *m*-carborane with 5,6-benzocoumarin and 5,6-benzo-3-ethoxycarbonylcoumarin have been studied.

Keywords: *o*,*m*-carborane, 5,6-benzocoumarin, 3,4-dihydrocoumarin, lithium derivatives of carborane

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We have recently shown [1–4] that reactions of lithium and magnesium derivatives of *o*-carboranes with coumarin and 3-ethoxycarbonylcoumarin occur regioselectively to form 4-(R-*o*-carboranyl)-3,4-dihydrocoumarins and 4-(R-*o*-carboranyl)-3-ethoxycarbonyl-3,4-dihydrocoumarins. Reactions of lithium and magnesium derivatives of isopropyl-*m*-carborane with 3-ethoxycarbonylcoumarin include sequential 1,2- and 1,4-addition to yield 3-isopropyl-*m*-carboranoyl-4-(isopropyl-*m*-carboranyl)-3,4-dihydrocoumarin.

Extending our previous studies on the chemistry of *C*-metallic derivatives of carboranes, herein we report the interaction of lithium derivatives of *o*- and *m*-carboranes with 5,6-benzocoumarin and 5,6-benzo-3-ethoxycarbonylcoumarin in diethyl ether–benzene medium.

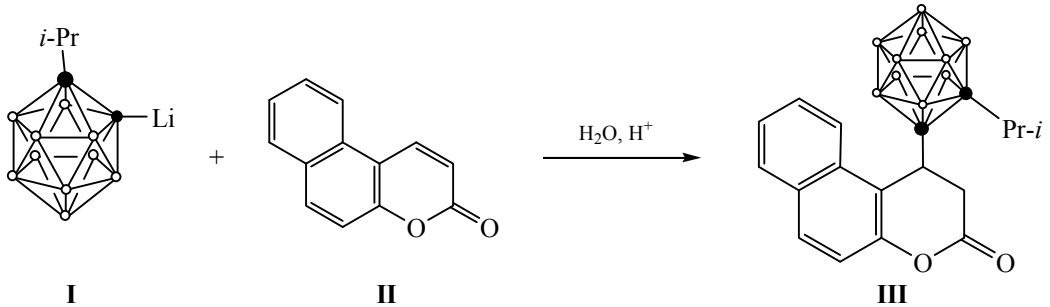
These reactions are of interest as yielding new data on the coupled addition reactions, as well as due to the importance of synthesis of novel carborane-containing coumarin derivatives with potential antitumor activity and other practically useful properties.

Lithium derivatives of isopropyl-*o*-carborane **I** reacted regioselectively with 5,6-benzocoumarin **II** to give the adduct **III** (Scheme 1).

The reactions of lithium derivatives of isopropyl-*o*- and -*m*-carboranes **Ia** and **Ib** with 5,6-benzo-3-ethoxycarbonylcoumarin **IV** proceeded ambiguously (Scheme 2).

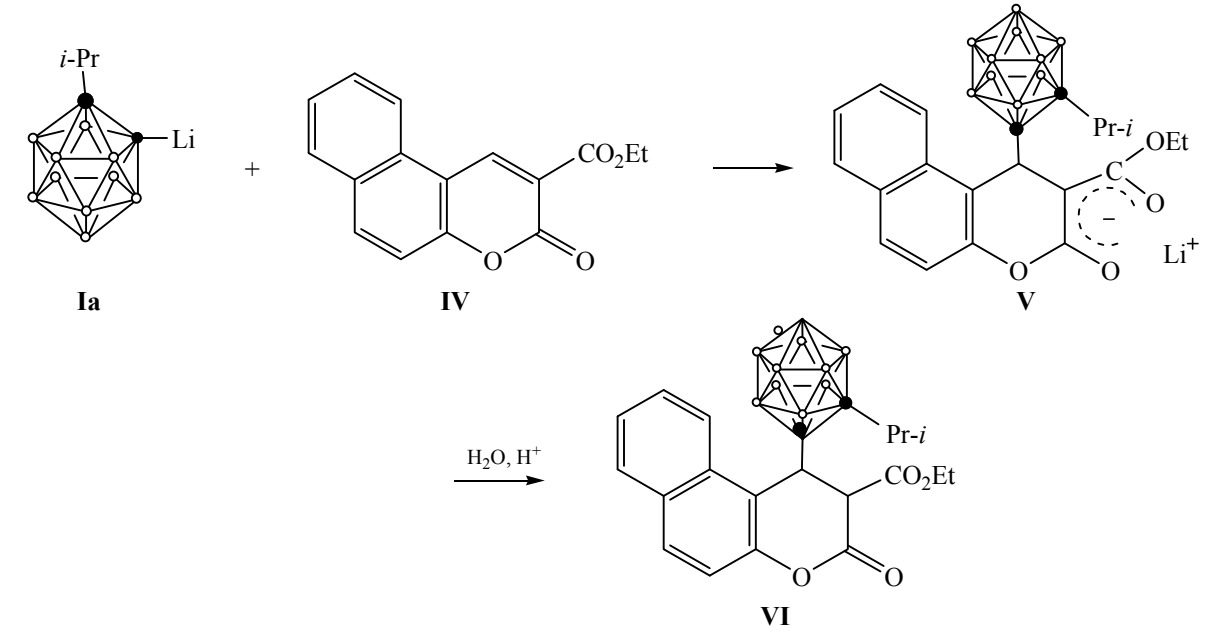
Isopropyl-*o*-carboranyllithium **Ia** reacted with **IV** via the only pathway independently of the solvent nature, the reagents ratio and their mixing order, to form a resonance stabilized ambident adduct **V**; the

Scheme 1.

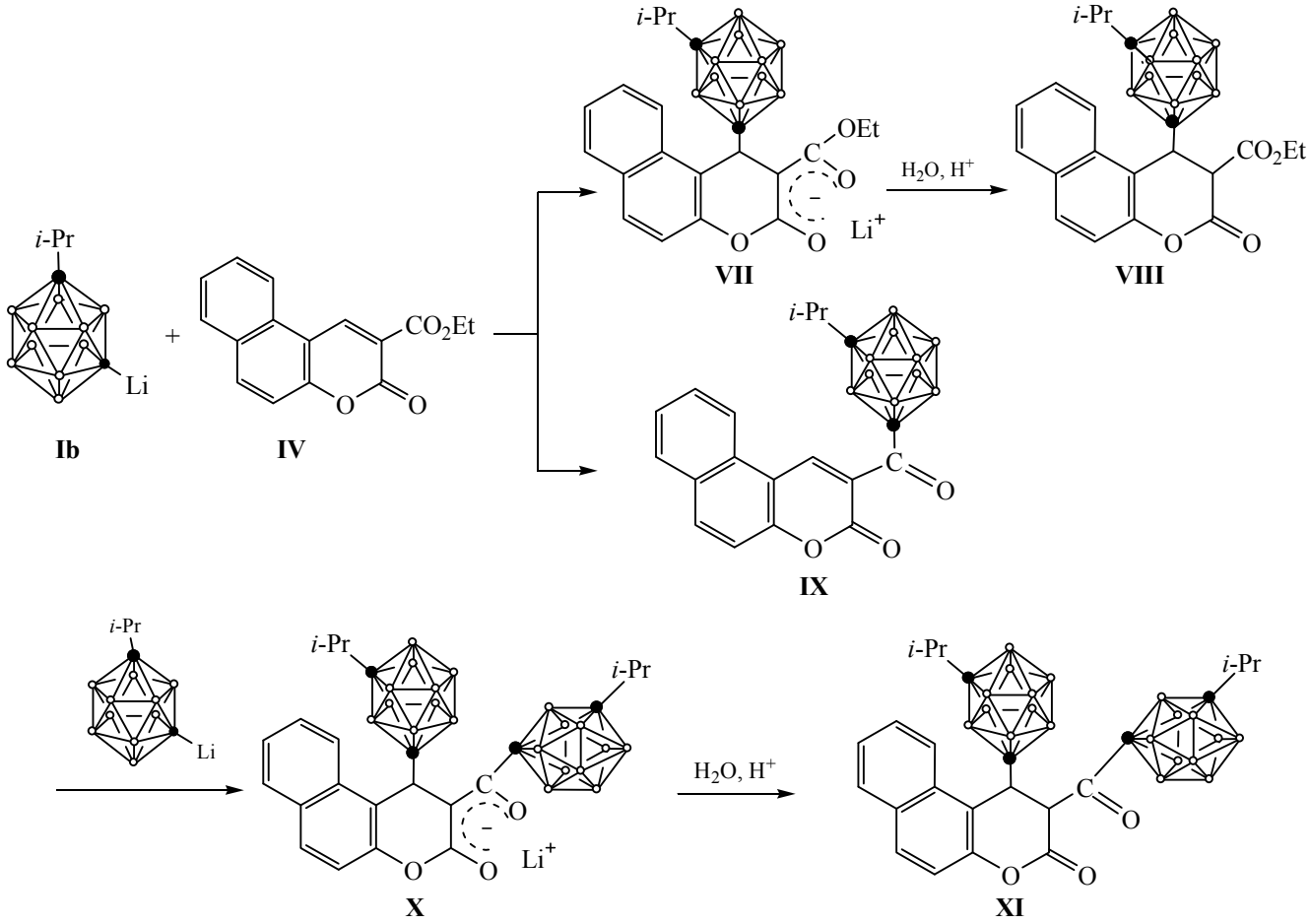


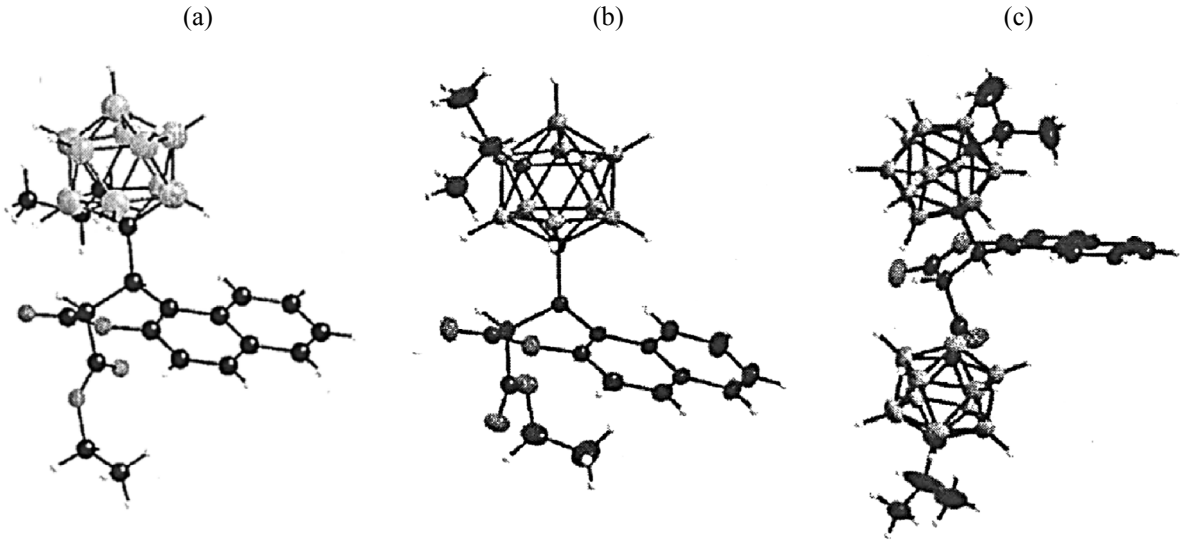
I **II** **III**

Scheme 2.



Scheme 3.





General view of molecules of (a) **VI**, (b) **VIII**, and (c) **XI**.

latter was treated with dilute HCl to yield 5,6-benzo-4-(isopropyl-*o*-carboranyl)-3,4-ethoxycarboranyl-3,4-dihydrocoumarin **VI** almost quantitatively.

Unlike **Ia**, isopropyl-*m*-carboranyllithium **Ib** reacted with **IV** via two directions to form 5,6-benzo-4-(isopropyl-*m*-carboranyl)-3-ethoxycarbonyl-3,4-dihydrocoumarin **VIII** and 5,6-benzo-3-(isopropyl-*m*-carboranoyl)-4-(isopropyl-*m*-carboranyl)-3,4-dihydrocoumarin **XI** (Scheme 3).

When the ratio of **Ib** to **IV** was of to 1 : 1, the yields of dihydrocoumarins **VIII** and **XI** were below 20%; at the ratio of 2 : 1 the yields reached 32 and 34%, respectively. Formation of dihydrocoumarin **VIII** was due to 1,4-addition; in the case of **XI,** the reaction included sequential 1,2- and then 1,4-additions, previously observed in the reactions of lithium derivatives of *m*-carborane with 3-ethoxycarbonylcoumarin.

Probably, the observed differences in the directions of lithiation reactions *o*- and *m*-carboranes **Ia** and **Ib** with 5,6-benzo-3-ethoxycarbonylcoumarin **IV** were caused by unequal nucleophilicity and selectivity of *o*- and *m*-carboranyl anions (generated from organometallic compounds) due to different electronegativity and delocalizing ability of *o*- and *m*-carborane moieties.

Structures of the synthesized dihydrocoumarins **III**, **VI**, **VIII** and **XI** were confirmed by IR, ^{1}H and ^{11}B NMR spectroscopy, mass spectrometry, and X-ray diffraction. General view of the molecules of **VI**, **VIII,** and **XI** is shown in the figure.

EXPERIMENTAL

IR spectra (KBr) were obtained with the BioRad FTS 155 instrument. ^{1}H and ^{11}B NMR spectra were registered with the Bruker DPX 200 spectrometer operating at 200 and 64.2 MHz, respectively. Mass spectra were recorded with the Bruker Esquire spectrometer.

5,6-Benzo-4-(isopropyl-*o*-carboranyl)-3,4-dihydrocoumarin (III). A solution of 1.96 g (10 mmol) of 5,6-benzocoumarin **II** in 10 mL of THF was added upon stirring at room temperature to a solution of 10 mmol of isopropyl-*o*-carboranyllithium **I** [prepared from 1.86 g (10 mmol) of isopropyl-*o*-carborane and 11 mmol of BuLi in 30 mL of the 4 : 1 benzene–diethyl ether mixture]. The reaction mixture was stirred at 20°C during 2 h, incubated overnight, treated with dilute HCl, and extracted with diethyl ether. The extract was dried with $MgSO_4$ and evaporated. The residue was crystallized from hexane. Yield 2.65 g (70%), mp 195–197°C (benzene–hexane, 1 : 1). IR spectrum, ν, cm^{-1}: 2985, 2932 (C–H); 2622, 2609, 2573 (B–H); 1774 (C=O). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.62–3.80 m (10H, BH), 1.44 d.d [6H, $(CH_3)_2CH$, *J* 10.27, 6.85 Hz], 2.54 septet [1H, $CH(CH_3)_2$, *J* 6.85 Hz], 2.99 d.d (1H, $CHCH_2$, *J* 16.87, 6.11 Hz), 3.21 d.d (1H, $CHCH_2$, *J* 16.63, 1.96 Hz), 4.53 d.d (1H, $CHCH_2$, *J* 6.11, 1.71 Hz), 7.33 d (1H, Ar), 7.49–7.57 m (1H, Ar), 7.61–7.70 m (1H, Ar), 7.88–7.95 m (3H, Ar). ^{11}B NMR spectrum ($CDCl_3$), δ_B, ppm: –3.69 (2B), –10.53 (4B), –12.14 (4B). Mass spectrum (EI), *m*/*z* (I_{rel}, %): 197 (100) $[M - CB_{10}H_{10}CCH(CH_3)_2]^+$, 382 (24) $[M]^+$.

5,6-Benzo-4-(isopropyl-*o*-carboranyl)-3-ethoxycarbonyl-3,4-dihydrocoumarin (VI) was prepared similarly from 10 mmol isopropyl-*o*-carboranyllithium **Ia** and 10 mmol of 5,6-benzo-3-ethoxycarbonylcoumarin **IV**. Yield 88%, mp 186–188°C (hexane–ethyl acetate). IR spectrum, ν, cm^{-1}: 3022, 2976, 2938 (C–H); 2631, 2619, 2586 (B–H); 1771, 1736 (C=O). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.51–3.70 m (10H, BH), 0.88 t (3H, CH_3CH_2, *J* 7.09 Hz), 1.48 d.d [6H, $(CH_3)_2CH$, *J* 17.61, 6.85 Hz], 2.68 septet [1H, $(CH_3)_2CH$, *J* 6.85 Hz], 3.97 q (2H, CH_2CH_3, *J* 7.17 Hz), 4.14 d (1H, CH, *J* 1.47 Hz), 5.02 d (1H, CH, *J* 1.47 Hz), 7.31 d (1H, Ar, *J* 8.80 Hz), 7.49–7.57 m (1H, Ar), 7.62–7.71 m (1H, Ar), 7.86–7.98 m (3H, Ar). ^{11}B NMR spectrum ($CDCl_3$), δ_B, ppm: –3.57 (2B), –10.44 (4B), –12.17 (4B). Mass spectrum (EI), *m*/*z* (I_{rel}, %): 197 (100) $[M - COOC_2H_5 - CB_{10}H_{10}CCH(CH_3)_2]^+$, 381 (15) $[M - COOC_2H_5]^+$, 454 (85) $[M]^+$.

Similar reaction of 10 mmol of isopropyl-*m*-carboranyllithium **Ib** and 5 mmol of 5,6-benzo-3-ethoxycarbonylcoumarin **IV** resulted in 5,6-benzo-4-(isopropyl-*m*-carboranyl)-3-ethoxycarbonyl-3,4-dihydrocoumarin **VIII** and 5,6-benzo-3-(isopropyl-*m*-carboranoyl)-4-(isopropyl-*m*-carboranyl)-3,4-dihydrocoumarin **XI**.

5,6-Benzo-4-(isopropyl-*m*-carboranyl)-3-ethoxycarbonyl-3,4-dihydrocoumarin (VIII). Yield 32%, mp 141–142°C (benzene–hexane). IR spectrum, ν, cm^{-1}: 3072, 2972, 2953, 2912 (C–H); 2605 (B–H); 1783, 1718 (C=O). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.70–3.7 m (10H, B–H), 0.88 t (3H, CH_3CH_2, *J* 7.58 Hz), 0.93 d [6H, $(CH_3)_2CH$, *J* 6.85 Hz], 2.09 septet [1H, $CH(CH_3)_2$, *J* 6.93 Hz], 3.95 q (2H, CH_3CH_2, *J* 7.17 Hz), 4.13 d (1H, CH, *J* 1.47 Hz), 4.71 d (1H, CH, *J* 1.47 Hz), 7.28 d (1H, Ar, *J* 9.29 Hz), 7.46-–7.54 m (1H, Ar), 7.60–7.68 m (1H, Ar), 7.83–7.89 m (2H, Ar), 8.00 d (1H, Ar, *J* 8.31 Hz). ^{11}B NMR spectrum ($CDCl_3$), δ_B, ppm: –3.78 (1B), –7.00 (2B), –10.82 (5B), –13.99 (2B). Mass spectrum (EI), *m*/*z* (I_{rel}, %): 197 (75) $[M - COOC_2H_5 - CB_{10}H_{10}CCH(CH_3)_2]^+$, 381 (20) $[M - COOC_2H_5]^+$, 454 (100) $[M]^+$.

5,6-Benzo-3-(isopropyl-*m*-carboranoyl)-4-(isopropyl-*m*-carboranyl)-3,4-dihydrocoumarin (XI). Yield 34%, mp 150–152°C (benzene–hexane). IR spectrum, ν, cm^{-1}: 3020, 2970, 2943, 2884 (C–H); 2605 (B–H); 1780, 1710 (C=O). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.60–3.9 m (20H, B–H), 0.96 d.d [6H, $(CH_3)_2CH$, *J* 19.07, 6.85 Hz], 2.11 septet [1H, $CH(CH_3)_2$, *J* 6.77 Hz], 4.44 s (1H, CH), 4.57 s (1H, CH), 7.30 d (1H, Ar, *J* 6.36 Hz), 7.52 t (1H, Ar, *J* 6.85 Hz), 7.66 t (1H, Ar, *J* 7.09 Hz), 7.78 d (1H, Ar, *J* 8.80), 7.90 t (2H, Ar, *J* 7.09 Hz). ^{11}B NMR spectrum ($CDCl_3$), δ_B, ppm: –3.79 (2B), –7.01(4B), –10.82 (10B), –13.99 (4B). Mass spectrum (EI), *m*/*z* (I_{rel}, %): 197 $[M - CB_{10}H_{10}CCH(CH_3)_2 - COCB_{10}H_{10}CCH(CH_3)_2]^+$, 223 (15) $[M - CB_{10}H_{10}CCH(CH_3)_2]^+$, 410 (5) $[M - CB_{10}H_{10}CCH(CH_3)_2]^+$, 594 (100) $[M]^+$.

REFERENCES

1. Kazantsev, A.V., Aksartov, M.M., and Aksartova, L.M., *Metalloorg. Khim*., 1990, vol. 3, no. 6, p. 1345.
2. Kazantsev, A.V., Kazantsev, A.A., and Butyaikin, V.V., *Metalloorg. Khim*., 1992, vol. 5, no. 3, p. 570.
3. Kazantsev, A.V., Butyaikin, V.V., Otrashchenkov, E.A., Muldakhmetov, Z.M., *Izv. Akad. Nauk.*, 1995, no. 10, p. 2058.
4. Kazantsev, A.V., Otrashchenkov, E.A., Aksartov, M.M., Turdybekov, K.M., Yamovoi, V.I., and Adekenov, S.M., *Zh. Org. Khim.*, 2002, vol. 38, no. 11, p. 1691.