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(11) As might be expected, we do see some evidence of coupling of the R· and M· species in certain cases. This will be elaborated in the full paper. These considerations do not influence the thrust of the conclusions to be made here. In the absence of RX the only products from irradiation of M–M′ are M–M and M′–M′.
(12) National Science Foundation Predoctoral Fellow, 1975–present.
(13) Recipient of a Dreyfus Teacher-Scholar Grant, 1975–1980.

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Rearrangement of 5-Methyl-*closo*-2,4-dicarbaheptaborane

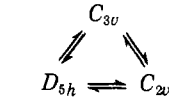
Sir:

Except for $(\eta\text{-}C_5H_5)_xCo_xC_2B_yH_{y+2}$ ($x = 1, y = 4$; $x = 2$, $y = 3$),[1] cage rearrangements among seven-vertex closo deltahedra are unknown. Furthermore, temperature-dependent studies on *closo*-$B_7H_7^{2-}$ show no structural pliability up to 90 °C for this pentagonal bipyramidal polyhedron on the NMR time scale.[2]

We find that 5-methyl-*closo*-2,4-dicarbaheptaborane (5-(CH_3)-2,4-$C_2B_5H_6$)[3] rearranges to an equilibrium 38:34:28% (±1% for each value) mixture of 1-, 3-, and 5-(CH_3)-2,4-$C_2B_5H_6$, respectively, at 300 °C over a 2-h period with no significant side reactions evident. The identity of the product mixture was established by (a) GLC–MS which exhibits only one slightly broadened GLC peak having the mass spectrum (PP = *m/e* 100) expected of a monomethyl derivative of $C_2B_5H_7$[4] with the only detectable impurity being a trace of a dimethyl derivative (PP = *m/e* 114) appearing at the tail end of the GLC peak; (b) a ^{11}B NMR comparison with other methyl derivatives of $C_2B_5H_7$[3] (the proton decoupled ^{11}B NMR exhibits peaks at δ +27.6, +20.6, +11.9, −3.9, −6.6, −8.3, −11.2, and −14.1, the pattern of which matched composite spectra for a mixture of 1-, 3-, and 5-$MeC_2B_5H_6$ based upon either known[3,5] or calculated[3] chemical shifts and assuming a 38:34:28 ratio for the three isomers, respectively; a similar comparison made using the undecoupled ^{11}B NMR spectra also supported the presence of all three *B*-$MeC_2B_5H_6$ isomers in the above quantity ratio); (c) a ^1H NMR spectrum containing three *B*-methyl peaks at τ 9.00 (3-Me), 9.28 (5-Me), and 10.50 (1-Me) in an area ratio of 1.25:1.00:1.39 (these shifts are nearly superimposable on the chemical shifts found for the 3-, 5-, and 1-methyl hydrogens, respectively, of a series of $(CH_3)_xC_2B_5H_{7-x}$ ($x = 1$–5) prepared by the Friedel–Crafts methylation of the parent carborane).[3]

When comparing the above observed equilibrium ratio with the statistical 40:20:40 (for 1-, 3-, 5-$MeC_2B_5H_6$) expected for a hypothetical situation where no enthalpy differences exist between the isomers, it is obvious from enthalpy considerations alone that the positional preference of the *B*-methyl group follows the order 3 > 1, 7 > 5, 6. It is interesting to note that this is in reverse order to that observed for electrophilic methyl substitution of the $C_2B_5H_7$ cage,[3] but a reversal of this genre is also seen when comparing the kinetically controlled Friedel–Crafts methylation of B_5H_9 (which exclusively favors the 1-, or apex, position)[6] with thermal equilibration results which favor the 2-, or basal, methyl isomer, 2-MeB_5H_8.[7] These results suggest that the positional preference of the methyl group due to the enthalpy contribution is on the boron with greatest positive charge. This is in agreement with a simple electrostatic polarization model[8] as applied to a *B*-methyl group.

In the course of the rearrangement it is probable that the methyl group does not migrate from boron to boron atom but, instead, accompanies its attached boron as the cage atoms undergo skeletal shifts. This is based on (a) the absence of significant quantities of $(CH_3)_xC_2B_5H_{7-x}$ ($x = 0$–7, $x \neq 1$) as side products which tend to rule out an intermolecular exchange mechanism expected of severe Me–B cleavage; and (b) the previous suggestion of a very plausible intramolecular skeletal rearrangement mechanism for a seven-atom cluster involving the stylized structural cycle:[9-15]



It is to be noted that this mechanistic scheme can lead to all possible *B*-methyl isomers. The substituted C_{2v} intermediate, a capped trigonal prism, contains two square faces as a result of two broken "edge" bonds, whereas the substituted C_{3v} intermediate, a capped octahedron, has evolved from a single diamond-square-diamond (dsd)[9] transformation which, at most, involves the breaking of only one "edge" bond of the starting pentagonal bipyramidal D_{5h} structure. Both the $D_{5h} \rightleftharpoons C_{3v}$ and the $D_{5h} \rightleftharpoons C_{2v}$ mechanistic schemes can involve identical dsd transformations with the subtle difference that the $D_{5h} \rightleftharpoons C_{2v}$ steps involve two concurrent dsd transformations occurring sequentially in the $D_{5h} \rightleftharpoons C_{3v}$ mechanism. Another plausible mechanistic scheme involving a rotating triangle rearrangement mechanism[1,15-18] may also account for the observed results.

The 5,6-di-, 1,5,6-tri-, and 1,5,6,7-tetramethyl derivatives of 2,4-$C_2B_5H_7$ also rearrange at 300 °C to isomers which, when analyzed, reinforce the stability trend 3 > 1, 7 > 5, 6 (for methyl-substituent placement) found for the monoethyl derivative. Related to these observations we note that the positional preference of the methyl group in a mixture of *B,B′*-$(CH_3)_2$-2,4-$C_2B_5H_5$ isomers formed from cage expansion of *closo*-1,6-$C_2B_4H_6$ with $B(CH_3)_3$ is nearly identical with that experienced from the rearrangement of 5,6-$(CH_3)_2$-2,4-$C_2B_5H_5$ at 300 °C.

Acknowledgment. Financial support from the National Science Foundation and the National Institutes of Health is acknowledged.

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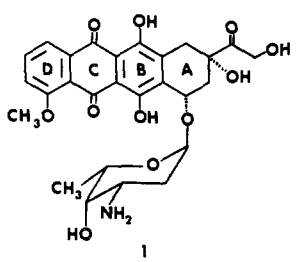
Regiochemical Control in the Diels–Alder Reactions of Substituted Naphthoquinones. Model Studies on a Regiospecific Approach to Adriamycinone

Sir:

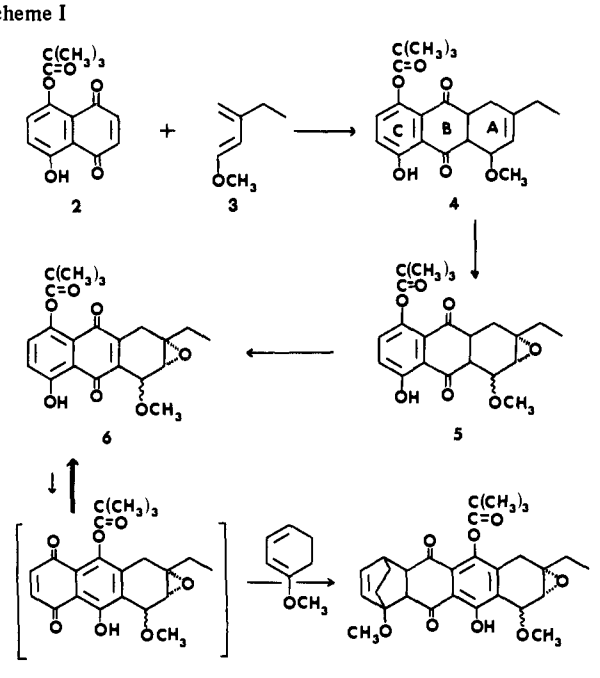
Adriamycin (**1**) and its analogues are dramatically efficacious in the treatment of a broad spectrum of human cancers.[1]



1

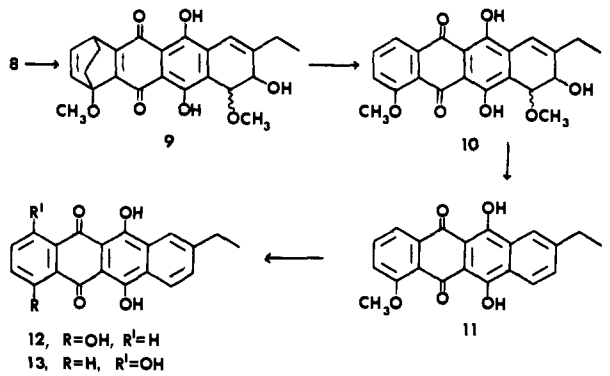
This fact, coupled with the intriguing structural and regiochemical challenges presented by these drugs, has stimulated intense efforts directed toward their total synthesis. To date practical solutions exist for the synthesis of the sugar portion of the molecule (daunosamine)[2] as well as for the coupling of daunosamine to the appropriate aglycones.[3] However, existing solutions[4,5] to the preparation of the aglycones, while noteworthy synthetic achievements, do not provide a method for controlling the relative orientation of the A- and D-ring substituents. We now wish to report the results of model studies which offer a potential solution to this regiochemical problem (Scheme I).

Scheme I



2 **3** **4** **5** **6** **7** **8**

Scheme II



9 **10** **11**

12, R=OH, R'=H
13, R=H, R'=OH

Reaction of naphthazarin monopivalate (**2**, orange crystals, mp 140.5–41 °C, prepared in 60–70% yield by treatment of naphthazarin with ~4 equiv of pivalic anhydride in benzene at 50–70 °C) with excess **3**[5a] in benzene or dichloromethane for 24 h at 25 °C gives **4** (mp 125–127 °C) in 92–99% yield. Attempts to oxidize the A–B ring junction of **4** were frustrated by concurrent aromatization of the A ring, but oxidation of epoxide **5** (off-white crystals, mp 119–120 °C, prepared from **4** in 90–95% yield by reaction with 2–3 equiv of *m*-chloroperbenzoic acid in CH_2Cl_2 for 2–5 days) with excess active lead dioxide[6] for 5–8 days at 60–70 °C in 1:1 dichloromethane–tetrachloroethylene (vigorous stirring) gives **6** (amber-orange crystals, mp 129–132 °C) in 50–65% yield. The stereochemistry of the A ring is not yet rigorously established. Reaction of **6** with 1.5–2 equiv of 1-methoxycyclohexa-1,3-diene[7] at 25 °C for 24 h in benzene or CH_2Cl_2 affords **8** (mp 157–159 °C) in 85–95% yield. The average overall yield of **8** from **2** is approximately 45%.

The key step **6** ⇆ [**7**] → **8** takes advantage of the unfavorable but facile equilibrium **6** ⇆ **7** which allows for the intramolecular transfer of the two directing (vide infra) groups. The minor[8] tautomer **7** is the more reactive dienophile and is trapped selectively, thereby providing a means of converting **6** to **8** through the intermediacy of **7**.[10]

Adduct **8** is obtained as a mixture of stereoisomers (the eventual elimination of the asymmetry introduced in the reaction **6** → **8** renders this lack of stereoselectivity inconsequential) but the regiochemical homogeneity of **8** was established unambiguously by conversion to **12** (Scheme II). Treatment of **8** with 0.5% aqueous KOH in ethanol–tetrahydrofuran for 4 h at 0 °C in the presence of oxygen gives **9**,[11] which yields **10** (red crystals, mp 212–214 °C) upon pyrolysis at 150–160 °C in ~90% overall yield. Hydrogenation of **10** (5% Pd/C, EtOAc) gives **11** (mp 202 °C) which affords **12** (mp 203–205 °C, lit.[12] 206 °C) upon treatment with excess BBr_3 in CH_2Cl_2 at −60 °C. Comparison[12] of spectra of the **12** so obtained with spectra[12] of authentic samples of **12** and the spectrally distinguishable alternative regioisomer **13** totally support the structure assigned to **12**. None of the regioisomer **13** could be detected. The regiospecific formation of **8** is thereby demonstrated.

The expectation that the Diels–Alder reactions of **2** and **7** would lead to the regiochemical consequences observed emerged from a consideration of the results and rationales of ourselves[5b] and others. Inhoffen, Muxfeldt, and coworkers[13] have reported that juglone (**14**) and its acetate (**15**) give opposite regiochemical results in their Diels–Alder reactions with 1-acetoxybutadiene, affording, as principal products, **16** and **17**, respectively. More recently, Powell and Birch have reported[14] that reaction of **14** with 1-methoxycyclohexa-1,3-diene gives exclusively **18**, explained[14] as being, in effect, a