Deamination of 1-Alkyl-9-aminomethyltriptycenes: Participation of the α-C-H Bond of the 1-Alkyl Group

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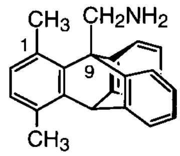
Diazotization of 1-alkyl-9-aminomethyltriptycenes (alkyl = methyl and ethyl) in AcOH or CHCl$_3$ gives products derived from participation of an α-C-H bond of the 1-alkyl group. The product distributions strongly depend on the 1-alkyl group and the solvent.

In 1987 we reported the diazotization of 9-aminomethyl-1,4-dimethyltriptycene (**1**) with nitrous acid (NaNO$_2$/HCl) in AcOH, which gave the cyclic hydrocarbon **2** (46%), the acetate **3** (34%), and the chloride **4** (8%) together with small amounts of skeletally rearranged homotriptycene derivatives.[1] We postulated that the C-H bond of the 1-methyl group participates in the decomposition of the predominant *ap*-rotamer **5** of the diazonium ion from the rear of the leaving N$_2$ to afford the pentacoordinate carbocationic species **6** with three-center two-electron bonding,[2] which either gives **2** upon loss of a proton or migrates to the benzylic cation **7**, the latter affording **3** and **4** upon addition of nucleophiles.



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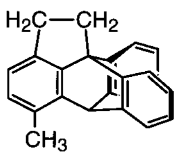

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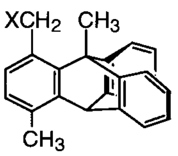
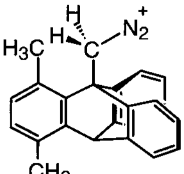


3: X = OAc
4: X = Cl



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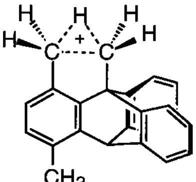

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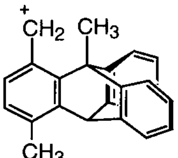

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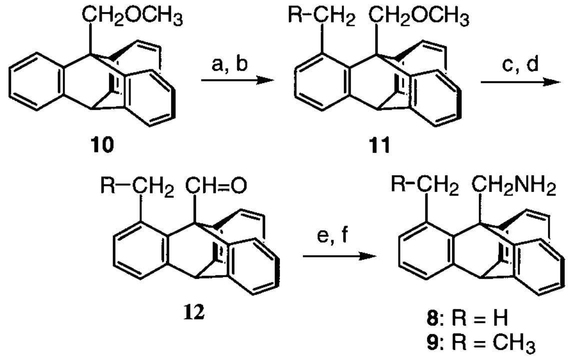
In order to have a deeper insight into the reaction, we began to examine the diazotization reactions of 9-aminomethyltriptycene derivatives with a variety of 1-substituents under various reaction conditions. In this article we report the results of diazotization of 9-aminomethyl-1-methyltriptycene (**8**) and 9-aminomethyl-1-ethyltriptycene (**9**) with isopentyl nitrite in CHCl$_3$ and AcOH.

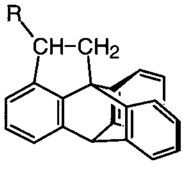
Compounds **8** and **9** were synthesized as shown in Scheme 1. In order to introduce a substituent selectively at position 1 of the triptycene skeleton, the directed lithiation method was employed. Thus the treatment of 9-methoxymethyltriptycene (**10**) with butyllithium caused lithiation at position 1,[3] and the Ni-catalyzed coupling with methyl iodide or ethyl bromide gave the 1-alkyl compounds **11** (R = H, 49%; R = CH$_3$, 43%). Cleavage of the methyl ether linkages in **11** with BBr$_3$ and oxidation of the resulted alcohols with PCC gave the aldehydes **12** (R = H, 84%; R = CH$_3$, 35%). Oximation of **12** followed by reduction of the oximes gave the desired amines **8** (63%) and **9** (44%).[4,5]



a) BuLi/TMEDA; b) CH$_3$I or C$_2$H$_5$Br/NiCl$_2$(DPPP); c) BBr$_3$; d) PCC; e) NH$_2$OH; f) LiAlH$_4$

Scheme 1.

The product distributions of the diazotization reactions[6] are summarized in Table 1.



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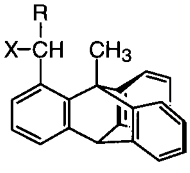

14: X = OAc
15: X = OH

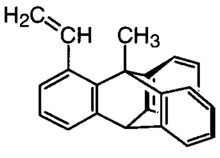

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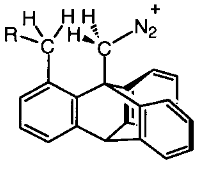
Table 1. Product Distributions (%)[a]

Compd	Solvent	13 (21)	14 (22)	15	16
8	AcOH	72	28	–	
	CHCl$_3$	98	2	–	
9	AcOH	–	100	–	–
	CHCl$_3$	5	61	5	29
20	AcOH	65	35	–	
	CHCl$_3$	97	3	–	

[a]Reliable to ±1%.

Diazotization of the 1-methyl compound **8** under the present conditions gave only the cyclized compound **13** (R = H) and the rearranged acetate **14** (R = H).[7] These results reinforce the previously given hypothesis for the intermediacy of the cationic species such as **6**.[1] Thus, in the predominant *ap*-rotamer **17** (R = H)[8] of the diazonium ion formed from **8**, a C-H bond of the 1-methyl group participates in the release of N_2 to give **18** (R = H), which either ejects a proton to give **13** (R = H) or rearranges to **19** (R = H) and the latter then gives **14** (R = H).



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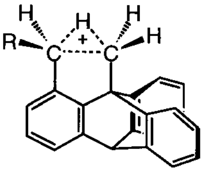

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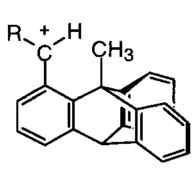

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The significant increase in the yield of **13** (R = H) and the decrease in that of **14** (R = H) upon changing the solvent from AcOH to $CHCl_3$ are noted. It is inferred that in $CHCl_3$ the cation **18** (R = H) may form a tighter ion pair with the counterion, presumably acetate, than in AcOH, and thus abstraction of the bridging hydrogen by the counterion may take place more efficiently in $CHCl_3$, or in other words, **18** is more long-lived in AcOH enough to have a chance to rearrange to **19**.

Table 1 shows that diazotization of the 1-ethyl compound **9** gave only the acetate **14** (R = CH_3) in AcOH but four products, **13**–**15** (R = CH_3) and **16**, in $CHCl_3$.[9] Compounds **14**–**15** (R = CH_3) and **16** are reasonably inferred to derive from the benzylic cation **19** (R = CH_3). It is noteworthy that the formation of the cyclized product **13** (R = CH_3) is strongly suppressed relative to the case of compound **8**. This may be ascribed to the greater stability of the secondary benzylic cation **19** (R = CH_3) than the primary one **19** (R = H), lowering the transition state leading to **19** from **18** for R = CH_3 relative to R = H.

In order to obtain further supporting evidence for the species **18**, we examined the 1-trideuteriomethyl compound **20**, which was synthesized similarly as **8**. Diazotization of **20** in AcOH and in $CHCl_3$ afforded **21** and **22** in the ratios given in Table 1. ^1H NMR spectra of the isolated **21** and **22** from either experiment gave the expected signal intensities for **21** and **22** and no H/D scrambling was detected.[11]

Despite considerable efforts, synthesis of the 1-isopropyl homolog **23** of **8** and **9** has yet been unsuccessful presumably because of steric hindrance. The results of diazotization of **23** would be interesting because the benzylic cation analogous to **19** might be sterically unfavorable. The efforts are still in progress.

References and Notes

1 G. Yamamoto and M. Ōki, *Chem. Lett.*, **1987**, 1163.

2 For recent theoretical studies of the protonated ethane $C_2H_7^+$, the prototype of **6**, see A. L. L. East, Z. F. Liu, C. McCague, K. Cheng, and J. S. Tse, *J. Phys. Chem. A*, **102**, 10903 (1998).

3 T. Kawase, N. Asai, T. Ogawa, and M. Oda, *J. Chem. Soc., Chem. Commun.*, **1990**, 339

4 Compounds **8** and **9** as well as most of the intermediate products gave satisfactory analytical and spectral data.

5 Compound **8**: mp 180–182 °C. ^1H NMR ($CDCl_3$) δ 1.68 (2H, br, NH_2), 2.57 (3H, br s), 4.68 (2H, br s), 5.29 (1H, s), 6.5–7.8 (11H, br m). Compound **9**: mp 137–138 °C. ^1H NMR ($CDCl_3$) δ 1.18 (3H, t, J = 7.5 Hz), 1.66 (2H, br, NH_2), 2.88 (2H, br q, J = 7.5 Hz), 4.72 (2H, br s), 5.29 (1H, s), 6.6–7.8 (11H, br m).

6 Diazotization was performed using 0.2 mmol of an amine and 30 μL (0.22 mmol) of isopentyl nitrite either in 5.0 mL of AcOH or in 5.0 mL of $CHCl_3$ containing 12 μL (0.21 mmol) of AcOH at room temperature for 4 h; at the end of the reaction, the amine had been completely consumed. The reaction mixture was mixed with diethyl ether, washed with water and dried over $MgSO_4$, and the product distributions were determined by ^1H NMR. The experiments were repeated three times. The products were separated by preparative gel permeation chromatography (GPC) and were fully characterized.

7 Compound **13** (R = H): mp 207–209 °C. ^1H NMR ($CDCl_3$) δ 3.23 (2H, m), 3.33 (2H, m), 5.46 (1H, s), 6.87 (1H, dd, J = 7.6 and 0.8 Hz), 6.90–7.03 (5H, m), 7.19 (1H, dd, J = 7.0 and 0.7 Hz), 7.31–7.44 (4H, m). Compound **14** (R = H): Oil. ^1H NMR ($CDCl_3$) δ 2.08 (3H, s), 2.65 (3H, s), 5.38 (1H, s), 5.39 (2H, s), 6.92–7.08 (6H, m), 7.34–7.43 (5H, m).

8 The ^1H NMR spectra of **8** and **9** at −45 °C in $CDCl_3$ showed that rotation about the C^9–CH_2 bond is frozen on the NMR time scale and the *ap*/±*sc* rotamer ratio is ca. 96/4 for either compound. Thus the diazonium ions **17** are reasonably assumed to exist predominantly as the *ap*-rotamer.

9 Compound **13** (R = CH_3): mp 165–167 °C. ^1H NMR ($CDCl_3$) δ 1.43 (3H, d, J = 7.1 Hz), 2.79 (1H, dd, J = 14.2 and 5.4 Hz), 3.51 (1H, dd, J = 14.2 and 8.7 Hz), 3.72 (1H, m), 5.47 (1H, s), 6.85 (1H, d, J = 7.7 Hz), 6.92–7.04 (5H, m), 7.21 (1H, d, J = 7.7 Hz), 7.33–7.43 (4H, m). Compound **14** (R = CH_3): mp 201–202 °C. ^1H NMR ($CDCl_3$) δ 1.46 (3H, d, J = 6.6 Hz), 2.01 (3H, s), 2.74 (3H, s), 5.35 (1H, s), 6.93–7.08 (6H, m), 7.19 (1H, dd, J = 8.1 and 1.4 Hz), 7.28 (1H, dd, J = 7.2 and 1.4 Hz), 7.32–7.50 (4H, m). Compound **15** (R = CH_3): mp 207–208 °C. ^1H NMR ($CDCl_3$) δ 1.31 (3H, d, J = 6.3 Hz), 1.58 (1H, br s), 2.69 (3H, s), 5.36 (1H, s), 5.92 (1H, q, J = 6.3 Hz), 6.98–7.10 (5H, m), 7.29 (1H, dd, J = 7.2 and 1.3 Hz), 7.34–7.43 (5H, m). Compound **16**: mp 194–195 °C. ^1H NMR ($CDCl_3$) δ 2.57 (3H, s), 5.24–5.30 (2H, m), 5.36 (1H, s), 6.88 (1H, dd, J = 7.8 and 2.0 Hz), 6.93 (1H, dd, J = 7.9 and 7.1 Hz), 6.97–7.07 (4H, m), 7.30 (1H, dd, J = 7.1 and 2.0 Hz), 7.33–7.40 (4H, m), 7.465 (1H, m).[10]

10 The ^1H NMR spectrum of **16** in $CDCl_3$ gives "deceptively simple" signals for the vinyl protons and at first puzzled us in assigning the structure. The spectral simulation using the LAOCN3 program (A. A. Bothner-By and S. Castellano, QCPE Program No. 111) finally confirmed the presence of a vinyl group: For $-CH^a{=}CH^bH^c$, δ_a = 7.465, δ_b = 5.275, δ_c = 5.287, J_{ab} = 10.9 Hz, J_{ac} = 17.0 Hz, and J_{bc} = 1.8 Hz.

11 Compound **21**: MS m/z 282 (M^+). ^1H NMR ($CDCl_3$) δ 3.23 (2H, s), 5.46 (1H, s), 6.87 (1H, dd, J = 7.6 and 0.8 Hz), 6.90–7.03 (5H, m), 7.19 (1H, dd, J = 7.0 and 0.7 Hz), 7.31–7.44 (4H, m). Compound **22**: MS m/z 343 (M^+). ^1H NMR ($CDCl_3$) δ 2.08 (3H, s), 2.64 (2H, s), 5.38 (1H, s), 6.92–7.08 (6H, m), 7.34–7.43 (5H, m).