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Notes

The Structure of Cacalone

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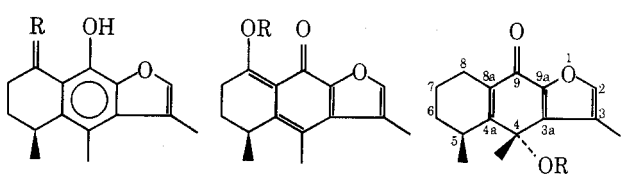
Cacalol and cacalone are two apparently related sesquiterpenes which have been isolated from the roots of *Cacalia decomposita*.[1,2] The present structures are **1a** and **2a**, respectively, which have evolved through a series of revisions.[2-4]

We have synthesized the ketone **1b**,[5] which is an aromatic tautomer of the previously proposed structure of cacalone **2a**.[4] The physical properties of compound **1b** were different from those reported for the natural cacalone,[1,2] as can be perceived from the data in Table I.

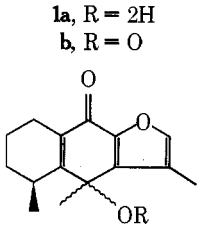
We describe here the chemical and spectroscopical data which demand alteration of the presently accepted structure of cacalone, and which strongly support structure **3a** instead.



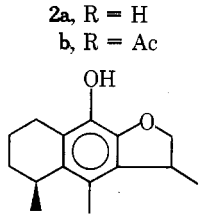
1a, R = 2H; **b**, R = O

2a, R = H; **b**, R = Ac

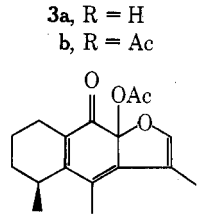
3a, R = H; **b**, R = Ac



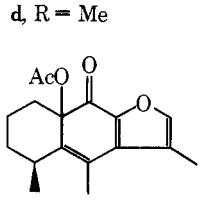
3c, R = H; **d**, R = Me



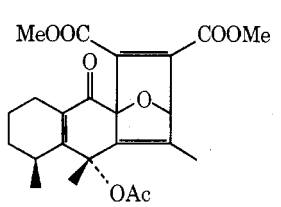
4



5



6



7

We found that natural cacalol (β-methyl)[2] suffers lead tetraacetate oxidation in benzene at room temperature, to produce cacalone acetate (mp 168–169 °C)[2] in good yield. Oxidation of substituted phenols by lead tetraacetate to *o*- or *p*-quinol acetates[6] serves as precedent for this type of conversion. This fact necessarily eliminates structure **2a** for cacalone. Mild alkaline hydrolysis of cacalone acetate ($KHCO_3$–H_2O–MeOH) affords cacalone identical with that obtained from the natural source, and its epimer at C-4.

Dehydration of cacalone using a variety of dehydration agents has been ineffective or has produced polymeric products. Hydrogenation of cacalone acetate (5% Pd/C, AcOEt) or pyrolysis through a heated tube[7] at 480 °C yielded cacalol **1a**. Cacalone hydrogenation (10% Pd/C in MeOH) has afforded dihydrocacalol **4**.[1] On the basis of these data and spectroscopic studies (see below) the structure **3a** (4-hydroxy-5,6,7,8-tetrahydro-3,4,5-trimethylnaphtho[2,3-*b*]furan-9(4*H*)-one) has been assigned to natural cacalone.

Among the three alternative structures (**3b**, **5**, and **6**) for cacalone acetate, which are conceivable as products of oxidation of cacalol **1a**, **5** was eliminated according to the following considerations.

Cacalone acetate affords a Diels–Alder adduct **7** when reacted with dimethyl acetylenedicarboxylate in boiling xylene. The adduct structure was established from its NMR spectrum, exhibiting a single peak at δ 5.96 for the proton at C-2 instead of the vinylic proton of cacalone acetate at 7.3 ppm. There also appear two singlets (3 H each) at 3.71 and 3.85 ppm corresponding to nonequivalent methyl ester groups. The fact that cacalone acetate forms a methyl ether **3d** (HCl_{aq}–MeOH) provides additional evidence for structure **3b** and further eliminates structure **5**, since the latter one has a ketal function. While these evidences do not distinguish between structures **3b** and **6**, structure **3b** has been selected on the basis of (1) ^1H NMR and shift reagent experiments, (2) ^{13}C NMR, (3) mass spectrometry.

1. ^1H NMR. The NMR data are shown in Table II. The comparison of the proton spectrum of **3a** and **3b** with synthetic **1b** is self-explanatory. The main differences between **1b** and **3a** consist in the absorption of the methyl in the 4 position, the OH chemical shift (there is H bonding at 13.35 ppm in **1b**), the two other methyl signals, and the very small chemical shift difference observed for H-6 and H-7 protons

Table I. Comparisons of the Properties of the Ketones

	Ketone **1b**[a]	Cacalone[b]
Mp, °C	115	140–143
Ir, cm^{-1}	ν_{max} ($CHCl_3$) 3500–2700 and 1650	ν_{max} ($CHCl_3$) 3550 and 1660
NMR, δ	1.27 (d, J = 7 Hz, 3 H), ca. 2.0 (m, 2 H), 2.40 (d, J = 1 Hz, 3 H), 2.53 (s, 3 H), ca. 2.75 (m, 2 H), 3.42 (m, 1 H), 7.55 (q, J = 1 Hz, 1 H), and 14.2 ppm (s, 1 H, interchangeable with D_2O)[c]	1.26 (d, J = 7 Hz, 3 H), 1.66 (s, 3 H), ca. 1.80 (m, 5 H), 2.21 (d, J = 1 Hz, 3 H), ca. 2.40 (m, 2 H), 3.15 (m, 1 H), and 7.29 ppm (q, J = 1 Hz, 1 H)[c,d]
$FeCl_3$	Positive reaction (green)	Negative

[a] Reference 5. [b] References 1 and 2. [c] Taken in $CDCl_3$ using Me_4Si as internal reference. [d] From an authentic sample kindly provided by Dr. J. Romo.

Table II. A Nuclear Magnetic Resonance Comparison of Compounds 3a, 3b, and 1b[a]

Compd	H-2	H-5	H-6 H-7	H-8	CH_3-3	CH_3-4	CH_3-5	OH	CH_3CO
3a	6.95 q (1)	3.16 m	1.59 m	2.50 m	2.08 d (1)	1.53 s	1.12 d (7)	2.85 br	
3b[b]	6.85 q (1)	2.53 m	1.65 m	2.61 m	1.72 d (1)	1.38 s	1.05 d (7)		1.67 s
δ 0.12	6.95	2.65	2.00	3.14	1.81	1.55	1.15		1.76
δ 0.22	7.20	2.82	2.40	3.58	1.95	1.69	1.25		1.85
δ 0.36	7.37	2.96	2.70	4.10	2.01	1.91	1.35		1.94
1b	7.00 q (1.3)	2.95 m	1.47 m, 2.41 m		1.92 d (1.3)	2.14 s	0.92 d (7)	13.00 s	

[a] Spectra were determined on a Varian HA-100 spectrometer in C_6D_6 solutions using Me_4Si as internal standard. Values are given in δ units. Multiplicity of signals are designated as follows: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; br, broad. Numbers in parentheses denote coupling constant in hertz. [b] δ 0.12, 0.22, and 0.36, after addition of 0.12, 0.22, and 0.36 mol of $Eu(fod)_3$, respectively.

Table III. ^{13}C Chemical Shifts for 1b, 3a, and 3b[a]

Carbon	1b	3a	3b
2	145.8	140.5 (d)	139.3 (d)
3	112.1	120.2 (s)	118.5 (s)
3a	140.0	145.3 (s)	145.9 (s)
4	117.4	72.3 (s)	77.4 (s)
4a	135.2	144.3 (s)	144.5 (s)
5	28.8	28.0 (d)	28.4 (d)
6	28.9	21.6 (t)	21.6 (t)
7	33.0	16.0 (t)	16.2 (t)
8	200.5	30.3 (t)	30.5 (t)
8a	117.9	130.7 (s)	132.7 (s)
9	142.0	175.0 (s)	174.8 (s)
9a	148.7	161.6 (s)	158.2 (s)
CH_3-3	11.1	8.8 (q)	8.6 (q)
CH_3-4	13.8	27.2 (q)	28.0 (q)
CH_3-5	19.1	21.4 (q)	20.8 (q)
$OCOCH_3$			168.6 (s), 20.7 (q)

[a] Varian XL-100 in $CDCl_3$ solutions, using Me_4Si as internal standard; letters in parentheses denote multiplicity in off-resonance experiments.

in **3a.** The shift reagents experiments on the acetate **3b** have shown that the H-8 signal has a much bigger shift (0.42 slope) and the other protons H-2 (0.10 slope) and CH_3-4 (0.14 slope) have the induced shift in a normal range. If cacalone acetate had structure **2b,** the acetate and the H-7 protons would be shifted more than observed as the favorite coordination site would be on the carbonyl at C-9. In addition, small homoallylic coupling (0.6 Hz) has been observed between protons 5 and 8.

The conformation of the cyclohexene part of **3a** is half chair and the relative position of CH_3-4 and CH_3-5 is cis. The absolute configuration of the C-5 asymmetric center of cacalone was established previously[2] as β. The orientation of the C-4 methyl group in **3a** was determined on the basis of the pyridine-induced solvent shifts[8] that were observed when the NMR spectrum of this compound and of its epimer in chloroform solution were compared with spectra determined in pyridine solution. Product **3a** does not show appreciable solvent effect on the signal corresponding to the C-5 methyl ($\Delta = \delta_{CDCl_3} - \delta_{C_5D_5N} = +0.04$), while its epimer exhibits substantial deshielding ($\Delta = -0.15$) for this methyl signal. On the other hand, the proton signal at C-5 in **3a** shows considerable deshielding ($\Delta = -0.20$), but in its epimer the shift of the proton is not so large ($\Delta = -0.10$).

2. ^{13}C NMR. The identification of all carbon signals of compounds **1b, 3a,** and **3b** has been done with the help of the off-resonance experiments (Table III). The ensemble of signals for **1b** and **3a,b** confirms our proposition of structures for both furan[9] and the unsaturated ketone[10] parts of the molecule.

The comparison of spectra on these series has shown that the only possible structure for natural cacalone is in fact **3a.** The spectra exhibit some particularities. The signal at 72 ppm corresponding to C-4 of the alcohol is shifted to 77 ppm after acetylation ($\Delta\delta$ = 5 ppm). The furan C-2 carbon is shifted by 5 ppm in **1b** compared to **3a.** The carbonyl C-8 signal of **1b** is around 200 ppm; however, for the 3 series the carbonyl C-9 absorption is in the 175-ppm range.

The prediction of the methyl chemical shift of the CH_3-4 and CH_3-5 trying a number of gauche and nonbonded interaction calculations,[11] using benzoquinones[12] or unsaturated ketones models,[13] confirms again our propositions. In spite of a zig-zag configuration of the oxygen lone pair to C-4, this methyl absorption is at 28 ppm only, because the lone pairs are oriented anti and eclipsed at the same time.[14]

3. Mass Spectrometry. The interpretation of the mass spectrum of natural cacalone and its acetate, done by Romo et al.,[4] was based on the assumption of the existence of a $M^+ + 2$ ion. The supposed $M^+ + 2$ ion is in reality the M^+ ion. Incidentally, *o*-benzoquinone type of structures lead to $M^+ + 2$ ions but, according to Djerassi, "caution must be exercised

Table IV. Mass Spectral Data of 1b and 3a[a]

1b	3a
244 (94%, M^+)	246 (66%, M^+)
230 (36%)	231 (32%)
229 (100%)	228 (42%)
215 (28%)	213 (48%)
201 (37%)	200 (56%)
187 (21%)	191 (100%)
173 (10%)	185 (25%)
128 (7%)	91 (30%)

[a] Spectra were determined on a Hitachi Perkin-Elmer RMU-7H spectrometer, 70 eV, 150 °C.

in the interpretation of such spectra in order to avoid misleading conclusions".[15]

The comparison of the mass spectra of **1b** and **3a** is done in Table IV. For the major fragmentation pathways (leading to 100% ions with the loss of CH_3 or C_4H_7 unit, respectively) the metastable ions have been observed. The corresponding acetates show a similar fragmentation pattern and loss of acetic acid has replaced dehydration.

Experimental Section

Melting points were taken on a Culatti capillary melting point apparatus and are uncorrected. The preparative TLC plates were Merck silica F-254. In order to follow the progress of the reactions or the purity of the compounds, Merck F-254 thin layer plates (250 μm), cut into small slides (5 by 2.5 cm), were used. Infrared spectra were taken on 521 or 567 Perkin-Elmer spectrophotometers. ^1H NMR spectra were obtained on Varian A-60A or HA-100 spectrometers in different solvents as indicated, with tetramethylsilane as internal reference, and are expressed as δ values, with the following abbreviations: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; br, broad. In double resonance experiments, a Hewlett-Packard audio oscillator Model 200 AB was used. The lanthanide shift reagent $Eu(fod)_3$ source was Bio-Rad Laboratories, Richmond, Calif. Carbon magnetic resonance data were obtained at 25.2 MHz with a Varian XL-100 spectrometer using tetramethylsilane as internal reference; *m/e* determinations were made on a Hitachi Perkin-Elmer RMU 7H mass spectrometer.

Oxidation of Cacalol 1a. To a solution of 2.3 g (10 mmol) of cacalol **1a** in 30 ml of benzene was added 3.22 g (7.2 mmol) of lead tetraacetate. The solution was stirred at 25 °C for 12 h. The lead acetate formed was filtered on Celite and washed with benzene. Excess of reagent was reduced by the addition of 2 ml of ethylene glycol and then 50 ml of water was added. The organic layer was washed with water and dried. Evaporation of the solvent gave an oily residue. The crude product was crystallized from acetone–hexane to afford 2.1 g (73%) of cacalone acetate **3b:** mp 168–169 °C; uv (95% EtOH) 211, 256, and 316 nm (ε 6100, 9900, and 7200); ir ($CHCl_3$) 1740 and 1660 cm^{-1}; NMR ($CDCl_3$) δ 1.29 (d, 3 H, J = 7 Hz, C-5 Me), ca. 1.65 (m, 4 H, C-6 and C-7 protons), 1.68 (s, 3 H, C-4 Me), 2.05 (d, 3 H, J = 1 Hz, C-3 Me), 2.08 (s, 3 H, OAc), ca. 2.45 (m, 3 H, C-5 and C-8 protons), and 7.30 ppm (q, 1 H, J = 1 Hz, C-2 proton); MS *m/e* 288 (M^+, 9%), 246 (100%), 228 (12%), 213 (21%), 191 (72%), 185 (10%), 43 (20%).

Alkaline Hydrolysis of Cacalone Acetate. A solution of 350 mg (3.5 mmol) of $KHCO_3$ in 5 ml of water and 20 ml of methanol was added to a solution of 1 g (3.47 mmol) of cacalone acetate **3b** in 50 ml of methanol. The resulting solution was heated to reflux for 20 h. After the methanol was evaporated, water was added and the mixture was extracted with ethyl acetate. The organic layer was washed with water, dried, and concentrated to give 700 mg (82%) of the oily mixture **3c,** epimeric at C-4 (ca. 1:1 by NMR). This mixture was chromatographed on eight preparative chromatoplates using benzene–ethyl acetate (98:2) as developing solvent. The plates were developed eight times. The more polar isomer was identical with the natural cacalone **3a:** mp 140–143 °C; uv (95% EtOH) 212, 250, and 320 nm; NMR (C_5D_5N) δ 1.22 (d, 3 H, J = 7 Hz, C-5 Me), ca. 1.60 (m, 4 H, C-6 and C-7 protons), 1.75 (s, 3 H, C-4 Me), 2.28 (d, 3 H, J = 1 Hz, C-3 Me), ca. 2.55 (m, 2 H, C-8 protons), ca. 3.35 (m, 1 H, C-5 proton), and 7.50 ppm (q, 1 H, J = 1 Hz, C-2 proton). For other spectroscopic data see Tables I–IV.

The less polar isomer shows spectroscopic constants identical with those of its epimer except the methyl signals at C-5 and at C-4 and the proton signal at C-5 in its NMR spectrum: mp 120–121 °C; NMR ($CDCl_3$) δ 1.29 (d, 3 H, J = 7 Hz, C-5 Me), 1.63 (s, 3 H, C-4 Me), ca. 1.80 (m, 5 H, C-6 and C-7 protons and OH), 2.21 (d, 3 H, J = 1 Hz, C-3 Me), ca. 2.40 (m; 2 H, C-8 protons), 2.90 (m, 1 H, C-5 proton), and 7.29 ppm (q, 1 H, J = 1 Hz, C-2 proton); NMR (C_5D_5N) δ 1.44 (d, 3 H, J = 7 Hz, C-5 Me), ca. 1.65 (m, 4 H, C-6 and C-7 protons), 1.70 (s, 3 H, C-4 Me), 2.26 (d, 3 H, J = 1 Hz, C-3 Me), ca. 2.60 (m, 2 H, C-8 protons), ca. 3.00 (m, 1 H, C-5 proton), and 7.53 ppm (q, 1 H, J = 1 Hz, C-2 proton).

Hydrogenation of Cacalone Acetate. A solution of 115 mg (0.4 mmol) of cacalone acetate **3b** in 25 ml of ethyl acetate was hydrogenated over 25 mg of 5% Pd/C at 25 °C for 12 h. The product was purified by chromatography in two preparative chromatoplates giving 100 mg (97%) of an oil. Crystallization of the product from acetone–hexane afforded cacalol **1a** as colorless crystals, mp 90–91 °C (lit.[1] 92–94 °C). For spectroscopic constants see ref 1, 2, and 5.

Pyrolysis of Cacalone Acetate. A solution of 144 mg (0.5 mmol) of cacalone acetate in 20 ml of toluene was injected through a pyrolysis tube[7] heated at 480 °C. The hot emerging gases were condensed in a trap cooled by dry ice. Evaporation of the toluene and recrystallization of the residue (acetone–hexane) gave 110 mg (95%) of cacalol **1a.**[1,2,5]

Hydrogenation of Cacalone. A solution of 170 mg (0.74 mmol) of cacalone **3a** in 40 ml of methanol was hydrogenated over 75 mg of 10% Pd/C at 25 °C until hydrogen absorption ceased. After filtration of the catalyst, the filtrate was concentrated and the product purified by TLC using benzene–ethyl acetate (95:5) as developing solvent. Elution with acetone yielded 75 mg (45%) of dihydrocacalol **4**[1] as a yellow oil which did not crystallize.

Formation of Adduct 7. A solution containing 300 mg (1.04 mmol) of cacalone acetate **3b,** 1.1 g (10 mmol) of dimethyl acetylenedicarboxylate, and 30 ml of xylene was heated at reflux for 12 h. Excess of reagent was evaporated under vacuum and the residue was chromatographed on six preparative chromatoplates using benzene–ethyl acetate (90:10) as developing solvent. The acetone eluates gave 180 mg (40%) of the adduct **7** as an oil: uv (95% EtOH) 218 and 330 nm (ε 11 500 and 4650); ir ($CHCl_3$) 1740 (b, OAc and methyl esters) and 1675 cm^{-1} (α,β-unsaturated ketone); NMR ($CDCl_3$) δ 1.12 (d, 3 H, J = 7 Hz, C-5 Me), ca. 1.71 (m, 4 H, C-6 and C-7 protons), 1.80 (s, 3 H, C-4 Me), 2.06 (s, 6 H, C-3 Me and OAc), ca. 2.40 (m, 2 H, C-8 protons), ca. 2.85 (m, 1 H, C-5 proton), 3.71 and 3.85 (s, 3 H each, nonequivalent methyl ester groups), and 5.96 ppm (s, 1 H, C-2 proton).

Methanolysis of Cacalone Acetate. A solution of 70 mg (0.24 mmol) of cacalone acetate **3b** in a mixture of 20 ml of methanol and 1 ml of 10% hydrochloric acid was heated at reflux for 30 min. The methanol was evaporated, water was added, and the product was extracted with ethyl acetate. The organic layer was washed with water, dried, and concentrated. The crude product was purified by TLC, obtaining 50 mg (87%) of the oily mixture **3d** (ca. 1:1 by NMR): ir ($CHCl_3$) 1660 cm^{-1}; NMR ($CDCl_3$) δ 1.26 and 1.29 (d, 3 H, J = 7 Hz, C-5 Me), 1.65 (s, 3 H, C-4 Me), ca. 1.70 (m, 4 H, C-6 and C-7 protons), 2.19 (d, 3 H, J = 1 Hz, C-3 Me), ca. 2.55 (m, 3 H, C-5 and C-8 protons), 2.90 and 2.93 (s, 3 H, OMe), and 7.40 ppm (q, 1 H, J = 1 Hz, C-2 proton).

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Registry No.—**1a,** 24393-79-1; **3a,** 26294-92-8; **3a** epimer, 60428-00-4; **3b,** 60428-01-5; 4*R*-**3d,** 60428-02-6; 4*S*-**3d,** 60428-03-7; **4,** 60428-04-8; **7,** 60428-05-9; dimethyl acetylenedicarboxylate, 762-42-5.

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Novel Formation of Anti-Bredt Olefins from 2,3,4,5,6,7-Hexahydro-1,6-methano-1*H*-4-benzazonin-7-ols

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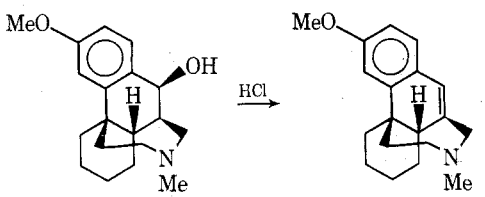
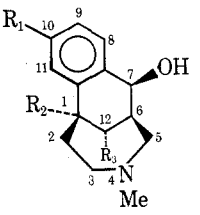
While there are many examples of formation of anti-Bredt olefins[1] by Hofmann elimination[2] or dehydrohalogenation[3] of the corresponding bridgehead substituted compounds or by dehalogenation[4] of 1,2-dihalo compounds, formation by elimination of compounds substituted adjacent to the bridgehead carbon is less common.[5] Recently, we reported that *B/C-cis*-6-methoxy-12-methyl-1,3,4,9,10,10a-hexahydro-2*H*-10,4a-methanoiminoethano-9β-phenanthrol (1), when treated with HCl, gave an olefinic compound **2** in violation of Bredt's rule.[6] This interesting result, which may be not only a new example of formation of anti-Bredt olefin but the first instance of the formation of anti-Bredt olefin under acidic condition, prompted us to examine reaction of the closely related 2,3,4,5,6,7-hexahydro-1,6-methano-1*H*-4-benzazonin-7β-ol[7] derivatives **3a–d** with HCl which might be expected to give similar results.

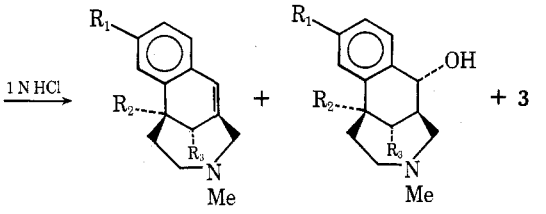


1 2

When 1,4,12α-trimethyl-10-methoxy-2,3,4,5,6,7-hexahydro-1,6-methano-1*H*-4-benzazonin-7β-ol (**3d**)[8] was refluxed with 1 N HCl for 1.5 h, anti-Bredt olefin **4d** was afforded in high yield. The structure of **4d** was confirmed from its NMR and mass spectra. In the NMR spectrum **4d** exhibited an olefinic proton signal at δ 6.16 (singlet). The mass spectrum showed a M^+ peak at *m/e* 257.1778 ($C_{17}H_{23}NO$). Treatment of 4-methyl- (**3a**),[9] 1,4-dimethyl- (**3b**), and 1,4-dimethyl-10-methoxy-2,3,4,5,6,7-hexahydro-1,6-methano-1*H*-4-benzazonin-7β-ol (**3c**)[8] with 1 N HCl gave the corresponding olefins **4a–c**, 7α-hydroxy[4] **5a–c**, and 7β-hydroxy compounds **3a–c** (product ratios are summarized in Table I), respectively. Each of the products was isolated by column chromatography and identified by NMR and/or mass spectrometry. The olefins **4a–c** exhibited, in the NMR, olefinic proton signals as singlets at δ 6.24 for **4a**, 6.25 for **4b**, and 6.27 for **4c**, respectively. The mass spectra showed M^+ at *m/e* 199.1370 ($C_{14}H_{17}N$) for **4a**, 213.1525 ($C_{15}H_{19}N$) for **4b**, and 243.1631 ($C_{16}H_{21}NO$) for **4c**,



3a, 3b, 3c, 3d



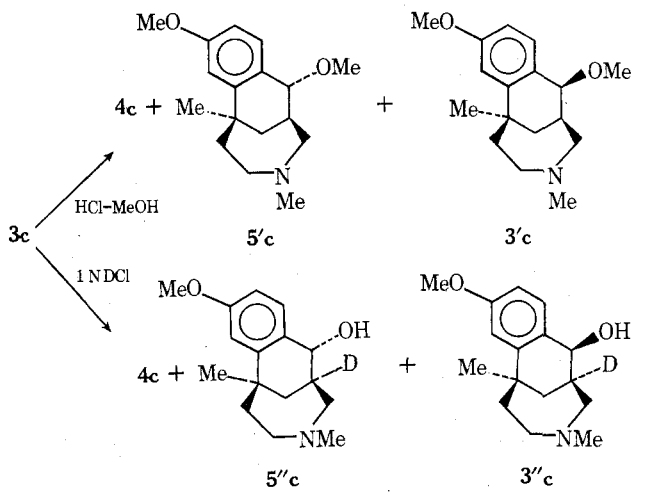
4a, 4b, 4c, 4d **5a, 5b, 5c,**

a, $R_1 = R_2 = R_3 = H$
b, $R_1 = R_3 = H$; $R_2 = Me$
c, $R_1 = OMe$; $R_2 = Me$; $R_3 = H$
d, $R_1 = OMe$; $R_2 = R_3 = Me$

respectively. The 7α-hydroxy isomers **5a–c** and the 7β-hydroxy isomers **3a–c** were easily distinguishable by NMR spectrometry, since the coupling constants of the C-7 proton with the C-6 proton of the former should be smaller than those of the latter (**5a**, 2.2 Hz at δ 4.26, vs. **3a**, 4.0 Hz at δ 4.88; **5b**, 2.8 Hz at δ 4.28, vs. **3b**, 5.5 Hz at δ 4.87; **5c**, 3.5 Hz at δ 4.26, vs. **3c**, 5.0 Hz at δ 4.83).

Reaction of 7α-hydroxy compound **5a** with 1 N HCl for 1.5 h gave a mixture of **3a, 4a,** and **5a.** Similarly, **5b** gave **3b, 4b,** and **5b.** Olefin **4a,** when refluxed with 1 N HCl, gave a mixture of **3a, 4a,** and **5a.** Similarly, **4b** gave **3b, 4b,** and **5b.** Under these conditions **4d,** however, was recovered unchanged.

When the reaction of compound **3c** with HCl was carried out in methanol a mixture of **4c,** 7β-methoxy **3'c,** and 7α-methoxy derivative **5'c** was afforded in the ratio 1:3:3 (by GLC). The structures of **3'c** and **5'c** were established by the NMR spectra and elemental analysis. We observed further that reaction of **3c** in 1 N DCl gave a mixture of olefin **4c,** 6-deuterio-7β-hydroxy **3''c,** and 6-deuterio-7α-hydroxy derivative **5''c** in the ratio 1:2:4 (by NMR). The incorporation of deuterium at the C-6 position was confirmed by the change of C-7 proton signals of **3c** and **5c** from doublet to singlet.



These experimental results made it evident that anti-Bredt olefins **4** are easily formed from the corresponding 7-hydroxy- (or methoxy-) 2,3,4,5,6,7-hexahydro-1,6-methano-1*H*-4-benzazonine derivatives **3** and **5** by treatment with acid, and that 7-hydroxy (or methoxy) derivatives **3** and **5** are formed, under these conditions, not by a simple substitution of the