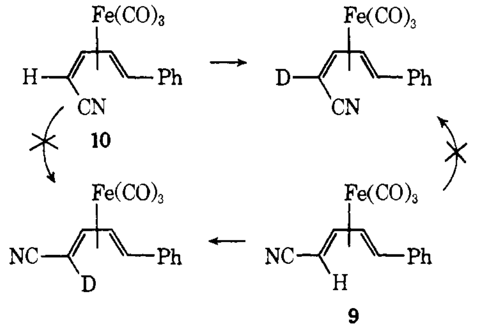
the basicity of the base employed. (4) The exchange is *stereospecific* about the exchanging carbon; **9** and **10** (eq 3) do not interconvert under the reaction conditions.[6] (5) There is a surprisingly large rate retardation in *cis*- relative to *trans*-nitrile complexes. The rate of exchange of the *cis*-nitrile **10** is approximately 100 times less than that of the *trans*-nitrile **9**, while the *cis,trans*-nitrile **12** is estimated to exchange approximately 10^3 times more slowly than the *trans,trans*-nitrile **11**. The case of **12** is noteworthy for the observed retarding effect of the *cis*-nitrile on exchange at both it and the *trans*-nitrile. (6) In the one case examined to date (**11** *vs.* ligand) the iron tricarbonyl group has only a small (*ca.* 2) retarding effect on the rate of exchange relative to that of the free ligand.


(3)

The above results are consistent with a process akin to the Michael addition–elimination mechanism for base-catalyzed H–D exchange of unsaturated nitriles and ketones.[7–9]

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(6) *Lack* of stereospecificity in a related reaction has been observed by C. H. DePuy and C. R. Jablonski, *Tetrahedron Lett.*, 3989 (1969).

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(9) Support by the National Science Foundation and National Institutes of Health is acknowledged.

(10) National Institutes of Health Predoctoral Fellow.

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Maytoline, a Nicotinoyl Sesquiterpene Alkaloid Prototype from *Maytenus ovatus*[1]

Sir:

We wish to report the structure of a new alkaloid, maytoline, isolated from *Maytenus ovatus* Loes., which is the prototype of a series of alkaloids present in members of the Celastraceae family. The alkaloids are characterized by the presence of a nicotinoyl ester substituted on a highly oxygenated sesquiterpene nucleus.

Maytoline (**1**), $C_{29}H_{37}NO_{13}$, was isolated from an aqueous ethanol extract of the fruit of *M. ovatus* Loes.[2] as a weakly basic amorphous powder:[3] uv$_{max}$ (MeOH) 221, 258 (infl), 265, 271 (infl) mμ (ε 9600, 2500, 2700, 2300); ir ($CHCl_3$) 2.85 (OH), 5.75 (ester carbonyl), 6.29 (pyridine) μ; mass spectrum *m/e* 607.2251 (M^+) (calcd 607.2264).

A second weakly basic alkaloid, maytine (**2**), $C_{29}H_{37}NO_{12}$, which was inseparable from **1** by tlc on silica gel but which had a higher R_f on alumina, was isolated as an amorphous powder: uv$_{max}$ (MeOH) 221, 258 (infl), 265, 271 (infl) mμ (ε 10,700, 3200, 3300, 2700); ir ($CHCl_3$) 2.83 (OH), 5.73 (ester carbonyl), 6.29 (pyridine) μ; mass spectrum *m/e* 591.2316 (M^+) (calcd 591.2315). In acidic solutions the ultraviolet spectra of both **1** and **2** changed to λ_{max} 220 (infl), 257 (infl), 262, 268 (infl) mμ (ε 8300, 4300, 4800, 4200), and the chromophore could be assigned to a nicotinoyl group.[4] The presence of the nicotinoyl group was supported by the nmr spectra ($CDCl_3$ + D_2O) of both compounds, which contained signals assignable on the basis of spin-decoupling studies to the four protons on a 3-substituted pyridine ring[5] [τ 2.62 (dd, $J_{5',6'} = 5$, $J_{4',5'} = 8$ Hz, C-5′), 1.73 (dt, $J_{4',5'} = 8$, $J_{4',6'} = J_{2',4'} = 2$ Hz, C-4′), 1.21 (dd, $J_{5',6'} = 5$, $J_{4',6'} = 2$ Hz, C-6′), 0.77 (d, $J_{2',4'} = 2$ Hz, C-2′)]. In addition the mass spectra of **1** and **2** contained strong peaks at *m/e* 124.0397 ($C_6H_6NO_2$) and 106, which could be assigned to a nicotinoyl group. The mass spectra also showed that both compounds readily lost 15 (CH_3), 18 (H_2O), and 60 (CH_3CO_2H) mass units, but little other useful information could be obtained.

As well as the signals due to the pyridine ring, the nmr spectrum ($CDCl_3$) of **1** contained signals assignable to seven quaternary C-Me groups [τ 8.46 (6 H), 8.39, 8.35, 7.85, 7.82, 7.70], a proton on carbon carrying hydroxyl (τ 6.40, d, $J = 3.5$ Hz), a D_2O exchangeable proton (τ 6.36), and six protons on carbon carrying ester [τ 5.60 and 5.04 (AB quartet, $J = 13$ Hz, CH_2), 4.51 (bd, $J = 7.5$ Hz), 4.40 (t, $J = 3.5$ Hz), 4.09 (d, $J = 3.5$ Hz), 3.84 (s)]. From the signals at τ 6.40, 4.40, and 4.09, the presence of a $-CHOH-(CHOAc)_2-$ grouping could be proposed. In the spectrum of **2** the signal at τ 6.40 was absent and a signal at τ 4.53 (2 H) appeared as a multiplet; otherwise the spectra of the two compounds were very similar. Thus the partial structure $-CH_2-(CHOAc)_2-$ could be assigned to **2**.

On hydrogenation of **2** over Pt the pyridine ring was reduced to a Δ^2-piperideine, tetrahydromaytine, $C_{29}H_{41}NO_{12}$: λ_{max} 290 mμ (ε 13,600);[6] mass spectrum *m/e* 595.2628 (M^+) (calcd 595.2628).

Hydrolysis of **1** and **2** yielded maytol (**3**), $C_{15}H_{26}O_8$, and deoxymaytol (**4**), $C_{15}H_{26}O_7$, respectively, which were identified by mass spectrometry. The spectra lacked molecular ions but contained strong M − 15 peaks and peaks due to repeated losses of 18 mass units. The nmr spectra of **3** and **4** lacked signals below τ 5.0 but contained a multiplet at τ 5.0–6.5, assignable to protons on carbon carrying hydroxyl, and three signals at τ 8.0–8.3, assignable to quaternary C-methyl groups. Thus both **1** and **2** were partially

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(1) Supported by grants from the National Institutes of Health (No. HE-13184 and CA-11718) and the American Cancer Society (No. T-275).

(2) Fruit collected in Ethiopia in Jan 1968. The authors acknowledge the receipt of the dried plant material from Dr. Robert E. Perdue, Jr., U. S. Department of Agriculture (USDA), Beltsville, Md., in accordance with the program developed with the USDA by the Cancer Chemotherapy National Service Center.

(3) Molecular formulas were determined by a combination of elemental analysis and high-resolution mass spectrometry.

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(5) *Cf.* the nmr spectrum of nicotinamide in "NMR Spectra Catalog," Vol. 2, Varian Associates, Palo Alto, Calif., 1962, spectrum no. 453.

(6) *Cf.* N. F. Albertson, *J. Amer. Chem. Soc.*, 74, 3816 (1952).

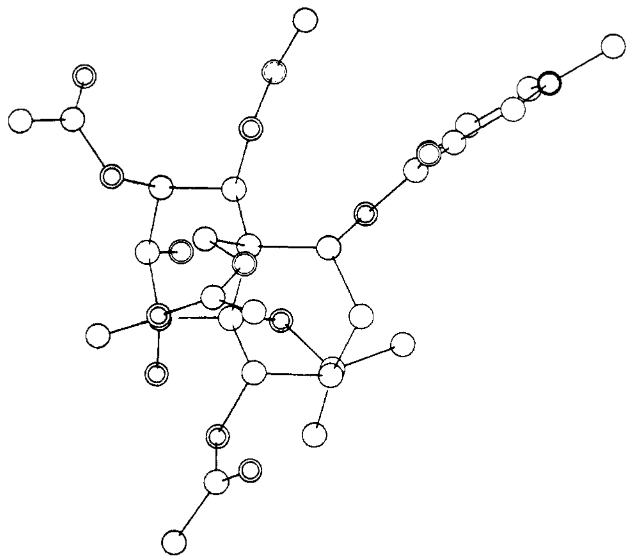


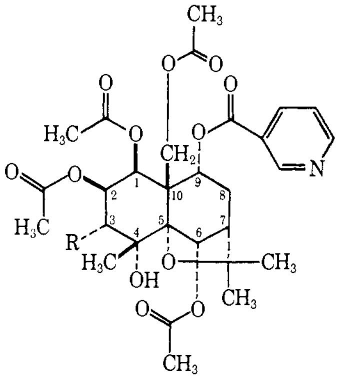
Figure 1. The maytoline methiodide cation as present in the crystal. Carbon atoms are denoted by single circles, oxygen atoms by double circles, and the nitrogen atom by the heavy circle.

characterized as containing a C_{15} nucleus carrying four acetate and one nicotinate ester groups and a tertiary hydroxyl group. **1** also contained a secondary hydroxyl group. One oxygen atom in each compound remained unassigned.

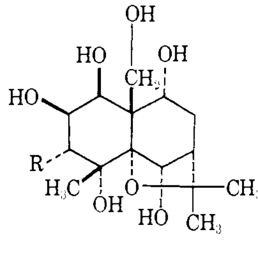
In order to determine the skeleton of the polyhydroxy nucleus and the locations of the acyl groups, the methiodide of **1** was prepared and examined by X-ray crystallography. Crystals of maytoline methiodide are monoclinic with space group $P2_1$, a = 11.643 (3), b = 14.621 (2), c = 10.436 (2) Å, β = 97.43 (1)°, and two molecules in the unit cell. The 1626 independent reflections significantly above background were measured by counter diffractometry with monochromatic Mo Kα radiation (λ 0.71069 Å). The structure was solved by the heavy-atom method and refined by use of the block-diagonal least-squares approximation to a final conventional R index of 0.076. Anisotropic thermal parameters were used only for the iodine atom. No reliable decision on the absolute configuration of the molecule could be made by examination of Friedel pairs or by independent refinement of the two possible enantiomeric structures taking account of the anomalous dispersion of the iodine atom. A view of the structure of the cation as found in the crystal is shown in Figure 1.

From the nmr spectral evidence, maytine (**2**) presumably lacked an oxygen function at C-1 or C-3. Of the seven C-Me signals in the nmr spectra of **1** and **2**, those below τ 8.0 are readily assignable to three acetyl groups. The remaining four signals τ 8.3–8.5 can thus be assigned to the three C-Me groups and to a shielded acetyl group. Examination of models of **1** showed that only the C-1 acetyl group methyl should come under the diamagnetic influence of the nicotinoyl ring. (See also Figure 1 for the relative orientation in the crystal.) As this high-field acetyl group signal was present in both spectra, maytine can be assigned the structure **2**. In the spectra of tetrahydromaytine this fourth acetyl group signal appeared at lower field, τ 8.18.

Maytoline's characteristics resemble those of "Alkaloid A," $C_{29}H_{37}NO_{13}$, a weak base isolated in 1949 from the fruit of *Euonymus europaeus* L. (Celastraceae).[7] Alkaloid A was shown to contain four acetyl groups and an acylable hydroxyl group, but no further work was carried out. More complex Celastraceae alkaloids were isolated subsequently from *Euonymus europaeus* L.[8] and *Tripterygium wilfordii* Hook,[9] but were only partially characterized. These compounds apparently contained a common $C_{15}H_{26}O_{10}$ decahydroxy nucleus, containing two C-methyl groups, which may be closely related to maytol. The nicotinic acids isolated from these compounds all contained a C_5-carboxylic acid substituent at the 2 position. Hence maytoline and maytine appear to be the first completely characterized members of a novel alkaloid family.



1, R = OH
2, R = H



3, R = OH
4, R = H

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Evidence for Epoxides as Intermediates in the Chromic Acid Oxidation of Olefins

Sir:

We recently presented kinetic evidence suggesting epoxide formation as the rate-limiting step in the Cr(VI) oxidation of olefins in aqueous acetic acid.[1] In this communication we wish to report the first successful trapping and isolation of an epoxide formed in a chromic acid oxidation of a simple olefin.[2]

We found that the oxidation of cyclohexene in glacial acetic acid containing perchloric acid yields a mixture of *cis*- and *trans*-2-acetoxycyclohexanol, a small amount of cyclopentanecarboxaldehyde, 2-hydroxycyclohexanone, and the allylic oxidation products 2-cyclohexen-1-ol and 2-cyclohexen-1-one (Table I, experiment

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