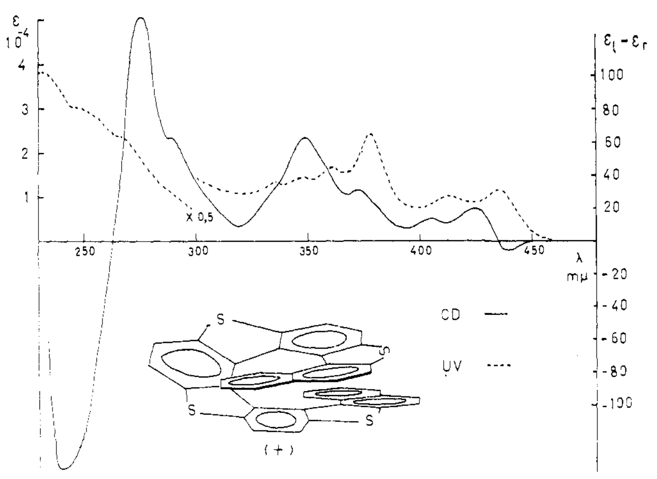
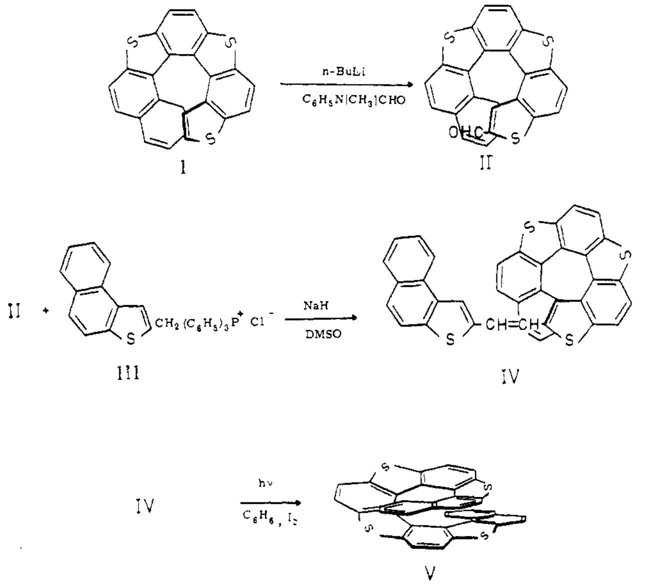
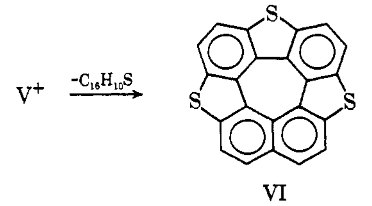


Figure 1. The uv spectrum (cyclohexane) and cd spectrum (methanol) of (+)-V.

specific rotation of optically pure V should be at least +3600° at 546 mμ and +2900° at 578 mμ. The calculated molar rotations are $[\phi]^{25}{}_{546}$ 22,000° and $[\phi]^{25}{}_{578}$ 17,000 (in $CHCl_3$). The uv and cd spectra of (+)-V are shown in Figure 1 and the nmr spectrum in Figure 2. The mass spectrum (70 eV) of V contained in addition to the strong M^+ (m/e 602) and M^{2+} peaks (m/e 301) a prominent peak at m/e 368 (25% relative to the M^+ peak) tentatively assigned to the planar ion VI. A metastable belonging to the fragmentation $V^+ \rightarrow VI$ is present also in the spectrum at m/e 226.





VI

These data unambigously establish the structure of V. Martin has recorded the optical activity of heptahelicene,[4] and optically active octa- and nonahelicene[5] have also been obtained in his Brussels laboratory. Of additional interest is the method we used to obtain optically active I. Instead of the crystal picking technique—which severely limits the scale of subsequent reactions—crystallization from optically active α-pinene, $[\alpha]^{25}{}_D$ −29.3° (neat), was successful. Thus 50-mg quantities of the heptaheterohelicene I were each dissolved in 10 ml of (−)-α-pinene with warming. The solutions were allowed to cool at room temperature or at −25°. The individual precipitates were each dissolved in 1.0 ml of chloroform and the optical rotations were measured in a 5-cm cell. The results are shown in Table I.

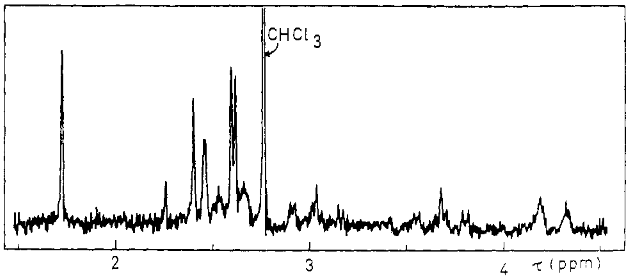


Figure 2. The nmr spectrum (60 MHz) of V (2% in $CDCl_3$).

Table I

Recovd heterohelicene, mg	Condn of crystalln, °C	Measured rotation, $\alpha^{25}{}_{436}$, deg	Specific rotation, $[\alpha]^{25}{}_{436}$, deg
7	−25 (4 days)	+3.60	+1000
13	−25 (1 day)	+2.43	+370
4	−25 (4 hr)	+4.27	+2400
16	+20 (1 day)	+0.27	+34

Repetition of these experiments using toluene–petroleum ether (1:1) or methylcyclohexane as solvent gave only optically inactive material, thus establishing that the optically active solvent has induced resolution.[6]

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(3) The melting point of (±)-V was 368–370°.

(4) R. H. Martin, M. Flammang-Barbieux, J. P. Cosyn, and M. Gelbcke, *Tetrahedron Lett.*, 3507 (1968).

(5) Personal communication from Professor Martin.

(6) We have not established conclusively at this time whether this resolution is thermodynamic in nature or simply due to preferential seeding (kinetic) or a combination of both! Few authenticated cases are known where resolution by crystallization from an optically active solvent is truly thermodynamic in nature [see, *e.g.*, D. R. Buss and T. Vermeulen, *Ind. Eng. Chem.*, **60** (8), 12 (1968)].

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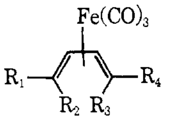
Base-Catalyzed Hydrogen–Deuterium Exchange in Diene–Iron Tricarbonyl Complexes

Sir:

We report that treatment of electronegatively substituted diene–iron tricarbonyl complexes with deuterated alcohols at 25° in the presence of base leads to hydrogen–deuterium exchange as in eq 1. Exchange is limited to those hydrogens α to the Z substituent. The position and extent of deuterium incorporation can be determined by nmr and mass spectrometry. The

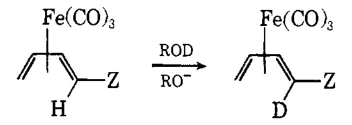
Table I. Exchange of Disubstituted Butadiene–Iron Tricarbonyl Complexes at 25° with Solvent Deuterons



Compd	R$_1$	R$_2$	R$_3$	R$_4$	Solvent[a]	Time, min	Yield, %	% d_1[b] A	% d_1[b] B
1	CH$_3$	H	H	CHO	*tert*-C$_4$H$_9$OD	60	28	80	82
					C$_2$H$_5$OH	60	92	100[c]	
2	Tol[d]	H	H	CHO	*tert*-C$_4$H$_9$OD	15	53	58	
					tert-C$_4$H$_9$OD	60	11	100[c]	
					C$_2$H$_5$OD	15	98	63	
					C$_2$H$_5$OD	60	90	100[c]	96
3	An[e]	H	H	CHO	C$_2$H$_5$OD	180	83	100[c]	
4	DCP[f]	H	H	CHO	CH$_3$OD	390	84	100[c]	
5	CH$_3$OOC	H	H	CHO	CH$_3$OD	12	61	68[k]	70
					CH$_3$OD	73	10	103	87% d_1, 8% d_2
6	Ph	H	H	COPh	CH$_3$OD	150[g]	100	18	
					CH$_8$OD	48 hr[g]	100	100[c]	
7	Ph	H	H	DCB[h]	CH$_3$OD	60[g]	98	51	
					CH$_3$OD	360[g]	100	100[c]	
8	Ph	H	H	COOCH$_3$	C$_2$H$_5$OD	60[g]	92[i]	<5	
					C$_2$H$_5$OD	142 hr[g]	97[i]	<5	
9	Ph	H	H	CN	C$_2$H$_5$OH	1.1	83	40	38
					C$_2$H$_5$OD	7	87	91	89
10	Ph	H	CN	H	C$_2$H$_5$OD	48	92	19	21
					C$_2$H$_5$OD	324	74	80	84
11	NC	H	H	CN	C$_2$H$_5$OD	1.0	67		36% d_1, 50% d_2
					C$_2$H$_5$OD	4.5	60	188	16% d_1, 83% d_2
12	NC	H	CN	H	C$_2$H$_5$OD	55	48		5[j]
					C$_2$H$_5$OD	120	23		13[j]

[a] The sodium or potassium salt (0.2 ± 0.1 *M*) of the solvent was used as base. [b] A, deuterium content determined by nmr; B, deuterium content determined by mass spectrometry. [c] No detectable signal for the exchanging hydrogen. [d] *p*-Tolyl. [e] *p*-Anisyl. [f] 3,4-Dichlorophenyl. [g] 20°. [h] 2,5-Dichlorobenzoyl. [i] The ethyl ester was isolated. [j] The positions(s) of exchange has not yet been determined. [k] Exchange was limited to the hydrogen α to the aldehyde group.

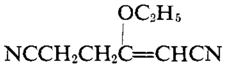
nmr spectra of these complexes show disappearance of the upfield absorption[1] due to those terminal protons exchanging and, in the case of aldehyde complexes, collapse of the C*H*O doublet to a singlet. Examples are presented in Table I.



(1)

Z = CHO, C≡N, COR

Side reactions normally associated with the free ligands involving enolate ions and irreversible Michael additions are absent. Under conditions wherein the *tetrahapto*iron tricarbonyl complexes of *trans*-2,4-pentadienal and *trans,trans*-1,4-dicyanobutadiene[2] are smoothly deuterated α to the formyl and cyano groups, respectively, the former free ligand is totally destroyed and the latter undergoes extensive cis–trans isomerization and (ultimately complete) conversion to the adduct.

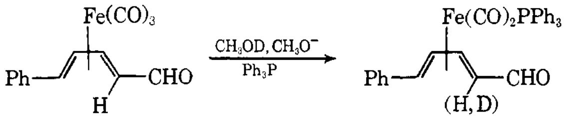


$$NCCH_2CH_2\overset{\displaystyle OC_2H_5}{\overset{|}{C}}{=}CHCN$$

Other examples of this protecting effect have been reported.[3,4]

The following procedure is representative. Into a 25-ml flask equipped with septum inlet, magnetic stirrer, and nitrogen inlet containing 0.74 mmol of sodium ethoxide in 4.0 ml of ethanol-*O*-*d* was injected a solution of 0.24 mmol of *trans,trans*-5-phenyl-2,4-pentadienenitrileiron tricarbonyl (**9**) in 1.2 ml of dry tetrahydrofuran. The resulting solution was stirred for 1.1 min under a nitrogen atmosphere at 25°. The reaction was quenched by the injection of 5 ml of deuterium oxide followed by hydrochloric acid. Aqueous work-up followed by chromatography on silica gel afforded an 83% yield of deuterated complex **9**, mp 168.5–171.5° dec.

The following observations are relevant to any mechanistic discussion of this reaction. (1) H–D exchange of aldehyde complexes in the presence of triphenylphosphine affords butadiene–iron dicarbonyl–triphenylphosphine[5] complexes as in eq 2. In the absence of base no reaction with triphenylphosphine occurs. The ligand exchange is accordingly associated with H–D exchange. (2) The dicarbonyl–triphenylphosphine



(2)

complexes thus prepared are not susceptible to H–D exchange in basic medium. (3) The rate of exchange parallels the electronegativity of the Z substituent (CN > CHO > COR > COOR) but does not parallel

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(1) G. F. Emerson, J. E. Mahler, R. Kochhar, and R. Pettit, *J. Org. Chem.*, 29, 3620 (1964).

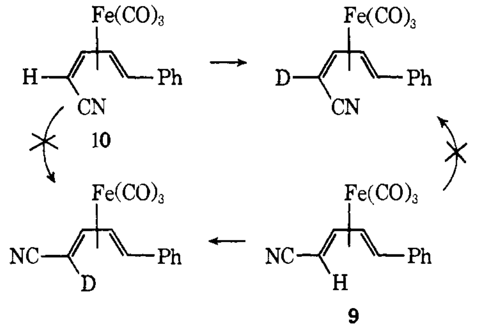
(2) All new compounds reported have satisfactory spectral properties and elemental analyses.

(3) C. H. DePuy, R. N. Greene, and T. E. Schroer, *Chem. Commun.*, 1225 (1968).

(4) A. J. Birch, P. E. Cross, J. Lewis, D. A. White, and S. B. Wild, *J. Chem. Soc. A*, 332 (1968).

(5) F. M. Chaudhari and P. L. Pauson, *J. Organometal. Chem.*, 5, 73 (1966).

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



(3)

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.

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]

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

[7] M. F. Zinn, T. M. Harris, D. G. Hill, and C. R. Hauser, *J. Amer. Chem. Soc.*, **85**, 71 (1963).

[8] B. W. Rockett, T. M. Harris, and C. R. Hauser, *ibid.*, **85**, 3491 (1963).

[9] Support by the National Science Foundation and National Institutes of Health is acknowledged.

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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.

[4] R. M. Acheson and G. A. Taylor, *J. Chem. Soc.*, 4140 (1959).

[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).