were washed with sodium carbonate solution and stored over anhydrous potassium carbonate. Probe temperature calibration and band-shape analyses were performed as described previously.[11]

2'-Phenylacetophenone (10 g, 95%) was prepared by reaction of the Grignard reagent from 2-iododiphenyl (12 g) with acetic anhydride (30 cm^3) in ether at −70 °C under nitrogen, bp 80 °C (0.1 Torr) (lit.[15], 104–105 °C (1.0 Torr)). The other ketones were obtained commercially.

***N*-[1-(2'-Methylphenyl)ethylidene]isopropylamine (1)** was obtained in 66% yield by refluxing 1-(2'-methylphenyl)ethanone (2.0 g), isopropylamine (16 cm^3), and titanium(IV) chloride (1.0 cm^3) in benzene for 3 h under nitrogen according to the procedure reported previously,[2] bp 58–60 °C (0.05 Torr).

Anal. Calcd for $C_{12}H_{17}N$: C, 82.2; H, 9.8; N, 8.0. Found: C, 82.2; H, 9.7; N, 7.8.

***N*-[1-(2'-Diphenyl)ethylidene]isopropylamine (2)** was similarly prepared from 2-phenylacetophenone (3.0 g), isopropylamine (20 cm^3), and titanium(IV) chloride (3.0 cm^3). Recrystallization from dry ethanol gave crystals of the *Z* isomer (2.3 g, 64%), mp 121 °C.

Anal. Calcd for $C_{17}H_{19}N$: C, 86.0; H, 8.1; N, 5.9. Found: C, 86.3; H, 8.4; N, 5.6.

***N*-[1-(2'-Nitrophenyl)ethylidene]isopropylamine (3)** was similarly obtained from 1-(2'-nitrophenyl)ethanone (3.0 g), isopropylamine (16 cm^3), and titanium(IV) chloride (1.5 cm^3). Distillation under reduced pressure followed by recrystallization from light petroleum afforded crystals of the *Z* isomer (2.2 g, 59%), mp 74–77 °C.

Anal. Calcd for $C_{11}H_{14}N_2O$: C, 64.0; H, 6.8; N, 13.6. Found: C. 64.25; H, 6.9; N, 13.7.

***N*-[1-(2'-Methoxyphenyl)ethylidene]isopropylamine (4)** was likewise obtained from 1-(2'-methoxyphenyl)ethanone (3 g) in 80% yield, bp 65 °C (0.05 Torr).

Anal. Calcd for $C_{12}H_{17}NO$: C, 75.35; H, 8.95; N, 7.3. Found: C, 75.6; H, 8.6; N, 7.2.

***N*-[1-(1'-Naphthyl)ethylidene]-2,2-dimethylpropylamine (10)** was similarly prepared in 45% yield from 1-(1'-naphthyl)ethanone (2 cm^3), 2,2-dimethylpropylamine (10 cm^3), and titanium(IV) chloride (1 cm^3), bp 110 °C (0.1 Torr).

Anal. Calcd for $C_{17}H_{21}N$: C, 85.35; H, 8.8; N, 5.85. Found: C, 85.6; H, 8.8; N, 5.6.

***N*-[1-(2',4',6'-Trimethylphenyl)ethylidene]-1-phenylethylamine (15)** was obtained in 50% yield from 1-(2',4',6'-trimethylphenyl)ethanone (2.0 g), (±)-1-phenylethylamine (16 cm^3), and titanium(IV) chloride (1.0 cm^3), bp 128–130 °C (0.1 Torr).

Anal. Calcd for $C_{19}H_{23}N$: C, 86.0; H, 8.7; N, 5.3. Found: C, 85.7; H, 9.0; N, 5.6.

Replacement of the $=CCH_3$ protons in **10** and **15** by deuterium was achieved by allowing a solution of the imine in deuteriomethanol (99.8%) to stand for a few hours. The solvent was then removed and the process repeated until NMR analysis showed that this methyl signal had essentially disappeared. Imine **5** has been reported previously.[2]

Acknowledgment. We thank the Science Research Council (U.K.) for an allocation of time on the 220-MHz NMR spectrometer at P.C.M.U. Harwell, and Riyadh University, Saudia Arabia, for a study grant to S.A.-S.

Registry No.—(*E*)-**1**, 66674-84-8; (*Z*)-**1**, 66674-85-9; (*E*)-**2**, 66674-86-0; (*Z*)-**2**, 66674-87-1; (*E*)-**3**, 66674-88-2; (*Z*)-**3**, 66674-89-3; (*E*)-**4**, 66674-90-6; (*Z*)-**4**, 66674-91-7; (*E*)-**5**, 38512-09-3; (*Z*)-**5**, 38512-03-7; (*E*)-**10**, 66674-92-8; (*Z*)-**10**, 66674-93-9; **15**, 66674-94-0; 2'-phenylacetophenone, 2142-66-7; 2-iododiphenyl, 2113-51-1; 1-(2'-methylphenyl)ethanone, 577-16-2; isopropylamine, 75-31-0; 1-(2'-nitrophenyl)ethanone, 577-59-3; 1-(2'-methoxyphenyl)ethanone, 579-74-8; 1-(1'-naphthyl)ethanone, 941-98-0; 2,2-dimethylpropylamine, 5813-64-9; 1-(2',4',6'-trimethylphenyl)ethanone, 1667-01-2; (±)-1-phenylethylamine, 618-36-0.

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New Furanoid *ent*-Clerodanes from *Baccharis tricuneata*[1]

Hildebert Wagner,* Renate Seitz, and Hermann Lotter

Institut für Pharmazeutische Arzneimittellehre der Universität München, D-8000 München 2, West Germany

Werner Herz*

Department of Chemistry, The Florida State University, Tallahassee, Florida 32306

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Because of the antitumor and antiviral properties of a crude extract, the constituents of the Colombian medicinal plant *Baccharis tricuneata* (L.f.) Pers. var. *tricuneata* have been investigated. The hexane extract yielded four new *ent*-clerodanes, bacchotricuneatins A–D (**1**, **2**, **3**, and **4a**), whose structures were elucidated, primarily by ^1H and ^{13}C NMR spectrometry. Proof for the structure and stereochemistry of A and B was obtained by X-ray analysis. Isolated from the ether extract were cirsimaritin, cirsiliol, and scopoletin.

Previous reports[2–4] on the pharmacological activity of some South American *Baccharis* species and their constituents made it of interest to examine the Colombian species *Baccharis tricuneata* (L.f.) Pers. var. *tricuneata*, which is widely used in folk medicine. Initial pharmacological screening revealed that an ethanol extract possessed significant antitumor and antiviral activity which corresponds to the medicinal use of the plant in Colombia;[5,6] consequently, we undertook a study of its constituents. We now wish to report the isolation and structure determination of four new closely related *ent*-clerodane diterpenoids, bacchotricuneatin A–D (**1**, **2**, **3**, and **4a**). The flavonoids cirsimaritin (**6a**) and cirsiliol (**6b**) and the coumarin scopoletin (**7**) were also isolated.[7]

The hexane extract of the aerial parts of *B. tricuneata*

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Table I. ^{1}H NMR Spectra of Bacchotricuneatins and Derivatives[a]

Compd	H-1	H-2	H-3	H-6	H-7	H-8	H-10	H-11	H-12	H-14	H-15	H-16	H-17	H-18	H-19	H-20	Misc.
1	1.25 m	2.45 m	6.77 dd	1.37 m	2.09[d]	2.68 dd	1.94[e]	2.13[d]	5.40 dd	6.43 t	7.48 br	7.43 t		3.94 dd		0.85[b]	
	1.77 m	2.27 m	(7, 3)	2.17[d]	1.91[e]	(14, 5.5)		1.94[e]	(11, 8)	(1)		(1)		(8, 2)			
														4.28 d			
														(8)			
2	1.21 m	2.35 m	6.67 dd	1.30 m	1.87 m	1.76[e]	1.80[e]	2.51 d[c]	5.46 t	6.37 br	7.46 t	7.44 br	1.14[b]	4.01 dd			
	1.70 m	2.22 m	(7, 2.5)	2.07 m	1.66 m			(8)	(8)		(1)		(6)	(9.5, 2)			
														4.65 d			
														(9.5)			
3	1.03 m	2.47 m	6.75 dd	1.38 m	2.11[e]	1.51 m	*g*	2.17[e]	4.95 t	6.37 br	7.41 br	7.37 br	5.22 br	3.88 dd		3.6 d	
	1.85 *f*	2.26 m	(7, 2.5)	2.04 m	1.85 *f*				(7)					(8, 2)		(9)	
														4.38 d		3.3 dd	
														(8)		(9, 1.5)	
4a		1.53[i]	5.51 m	1.58[i]	4.03 m	1.67[i]				6.24 br	7.34 br	7.18 t	1.04 d[b]	1.36[b]	4.12 br[c]	1.02[b]	
		2.22[h]	($W_{1/2}$ = 9)	2.15[h]	($W_{1/2}$ = 9)							(1)	(7)				
4b			5.52 br		4.04 m					6.23 br	7.34 br	7.18 br	1.05 d[b]	1.34[b]	4.5 br[b]	1.02[b]	2.07[b]
			($W_{1/2}$ = 9)		($W_{1/2}$ = 9)								(7)				(Ac)
4c			5.70 m			2.66 q				6.26 br	7.37 br	7.22 br	0.97 d[b]	1.06[b]	4.49 br[c]	0.75[b]	2.05[b]
			($W_{1/2}$ = 9)			(7)							(7)				(Ac)
5			6.55 dd		4.04 m					6.24 br	7.34 br	7.31 br	1.07 d[b]	1.44[b]	9.3 br	1.03[b]	
			(5, 4)		($W_{1/2}$ = 9)								(7)				

[a] Run in $CDCl_3$ solution with Me_4Si as internal standard. Chemical shifts are in ppm; figures in parentheses are coupling constants in hertz. Description: d, doublet; t, triplet; q, quartet; br, broadened singlet; m, multiplet. Unmarked signals are singlets. [b] Intensity of three protons. [c] Intensity of two protons. [d] In a four-proton multiplet. [e] In a three-proton multiplet. [f] In a two-proton multiplet. [g] Could not be identified. [h] In a five-proton envelope. [i] In a nine-proton envelope.

furnished, after extensive chromatography, three crystalline isomeric lactones $C_{20}H_{22}O_5$ (elemental analysis, high-resolution mass spectrometry), mp's 239–241, 191–192, and 188–189 °C, respectively, and one diol $C_{20}H_{30}O_3$, mp 106 °C, designated as bacchotricuneatin A, B, C, and D. All four compounds were β-monosubstituted furans as evidenced by IR absorptions at 3140, 1500, and 870 cm^{-1}, narrow multiplets in the ^{1}H NMR spectra at 7.4, 7.3, and 6.4 ppm, mass spectral fragments at *m/e* 95, 94, and 81,[8] and positive Ehrlich tests.[9] The UV spectrum of D showed only end absorption; in the UV spectra of A, B, and C this was masked by the absorption due to an α,β-unsaturated lactone group.[10]

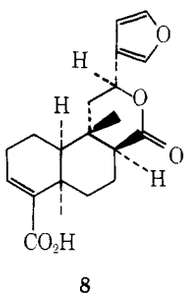
The major lactone, bacchotricuneatin A, was, like B and C, an α,β-unsaturated γ-lactone (IR bands at 1750 and 1645

cm^{-1}) of the type represented by partial formula I because of the presence in the NMR spectrum of a doublet of doublets

at 6.77 ppm, characteristic of the β proton on a double bond conjugated with a carbonyl group. This proton was further coupled to a methylene group (signals at 2.45 and 2.27 ppm). The ^{13}C NMR spectra of A and B indicated the absence of additional double bonds. Incidentally, all three lactones exhibited a positive Dragendorff reaction although lacking nitrogen,[11] but surprisingly they did not give the Kedde[12] and Baljet[13] tests.

The NMR spectra of A, B, and C also contained an AB system with a chemical shift characteristic of the methylene in the grouping $-C(=O)OCH_2-$, which was attached to a tertiary carbon atom. The upfield proton of this system (H-18a) was in turn long range coupled (J = 2.5 Hz) to another proton (at 1.37 ppm in A and B and at 1.30 ppm in C). This fact, together with extensive spin decoupling experiments on compounds A, B, and C, which will not be described in detail (see Table I), permitted, for all three lactones, expansion of I to partial structure II. Partial structure II is also present in *trans*-clerodanes recently isolated form *B. conferta*,[14] *B. trimera*,[15] and *B. articulata*.[16] The obvious possibility that the compounds from *B. tricuneata* might also possess a *trans*-clerodane skeleton was verified by the additional information to be presented in the sequel.

The NMR spectrum of A also displayed a doublet of doublets (J = 11 and 8 Hz, H-12) at 5.4 ppm which could be shown to be the X part of an ABX system where A and B (H-11) resonated at 2.13 and 1.94 ppm, respectively. The chemical shift of X, which was almost identical with that of H-12 in floribundic acid (8)[17] and related clerodanes,[18,19] together with the



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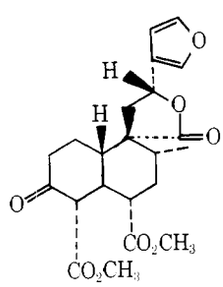

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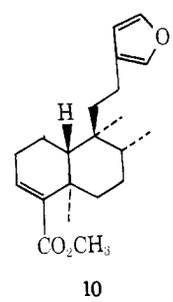

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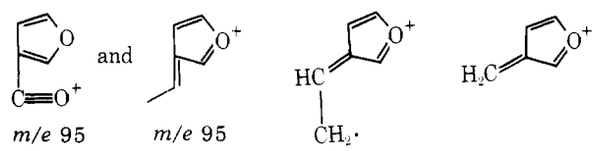
empirical formula which required two additional oxygen atoms pointed to the presence of a second lactone function probably closed to a position α to the furan ring. This was in agreement with a second carbonyl band in the IR spectrum characteristic of a δ-lactone (1725 cm^{-1}) and was supported by the ratio of the fragments IV, V, and VI in the mass spectrum (98, 90, and 20%). Whereas fragment VI predominates in furan derivatives with an unsubstituted side chain, IV and V predominate in lactones similar to bacchotricuneatin.[20a,b,22]



m/e 95 *m/e* 95 IV V, *m/e* 94 VI, *m/e* 81

The NMR spectrum of A also exhibited the methyl singlet of a tertiary methyl group which can only be located at C-9 of the assumed clerodane skeleton. Therefore, the missing secondary methyl ordinarily attached to C-8 was represented by the carbonyl group of the δ-lactone ring. This deduction was supported by identification of a rather deshielded doublet of doublets at 2.68 ppm as the signal of H-8; its coupling constants (J = 14 and 5.5 Hz) render obvious the equatorial attachment of the carbonyl group. Combination of all data thus led to formula 1 (for discussion of stereochemistry see below).

Table II. ^{13}C NMR Spectra of Bacchotricuneatins A, B, and D[a]

	1	2	4a
C-1	19.4 t	21.0 t	18.3 t[b]
C-2	27.6 t	28.0 t	26.4 t
C-3	135.8 d	134.3 d	121.6 d
C-4	137.9	139.4	148.5
C-5	45.0	45.4	38.2
C-6	32.8 t	33.6 t	39.6 t
C-7	20.0 t	28.0 t	73.5 d
C-8	53.7 d	43.2 d	39.2 d
C-9	36.9	50.9	37.2
C-10	47.4 d	49.5 d	46.4 d
C-11	43.4 t	42.0 t	42.3 t
C-12	69.9 d	71.8 d	17.3 t[b]
C-13	125.0	125.7	125.4
C-14	108.7 d	107.9 d	110.9 d
C-15	143.7 d	144.2 d	142.0 d
C-16	139.7 d	139.2 d	138.4 d
C-17	173.1	17.2 q	12.5 q
C-18	71.0	72.9 t	23.3 q
C-19	168.3	169.0	63.0 t
C-20	19.6 q	177.0	19.9 q

[a] Run at 67.9 MHz in $CDCl_3$ solution; shifts are in ppm. Unmarked signals are singlets. [b] Assignments may be interchanged.

The spectral properties of bacchotricuneatin B (2) closely resembled those of A. However, the two carbonyl bands of the IR spectrum had now collapsed to a single band of double intensity at 1745 cm^{-1}, and in the NMR spectrum the methyl singlet of A representing C-20 had been replaced by a doublet at 1.14 ppm, the proton responsible for the splitting being located at 1.76 ppm (H-8). The signal in the range of H-12 now appeared as a triplet [5.48 ppm (J = 8 Hz)], which was shown to be the X part of an ABX system with A and B (superposed in $CDCl_3$ at 2.41 ppm) as an eight-line multiplet exhibiting coupling constants of 8 and 14 Hz in C_5D_5N. These observations, together with biogenetic considerations, suggested that the structure of B contained a second saturated lactone ring linking an oxidized C-20 to C-12, the relationship of the furan and lactone moieties being similar to that found in corylifuran (9)[21] or teucvin.[22]

The decoupling experiments with bacchotricuneatin B also provided evidence that H-8 was adjacent to another methyl group which in turn was linked to a methylene group, one proton of which was long range coupled (W coupling) to H-18a. Accordingly, bacchotricuneatin A, B, and C (see below), all of which exhibited this long range coupling, seemed to possess the same trans stereochemistry as the *ent*-clerodanes from *B. trimera*[15] and *conferta*.[14] The equatorial orientation of the C-8 substituent was evident from the values of $J_{7,8}$. In the case of 1, the chemical shift of H-20, essentially identical with that of the compounds from *B. trimera*, pointed to axial orientation of the methyl group on C-9. In the case of 2, the downfield shift of H-18b could be rationalized by assuming that the lactone carbonyl on C-9 was axial, thus bringing H-18 within its deshielding region (models). The relative stereochemistry of bacchotricuneatin A and B was therefore that shown in formulas 1 and 2, with the exception of the stereochemistry at C-12, which could not be deduced chemically or spectroscopically.

The ^{13}C NMR spectra of 1 and 2 (Table II) provided strong support for the postulated structures. Peaks with suitable shifts and off-resonance multiplicities were found for each of the carbon atoms and could be assigned by application of the usual shift parameters and comparison with data in the lit-

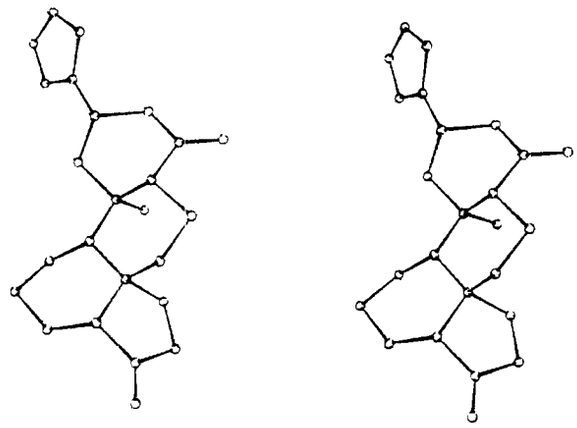


Figure 1. Stereoscopic view of bacchotricuneatin A.

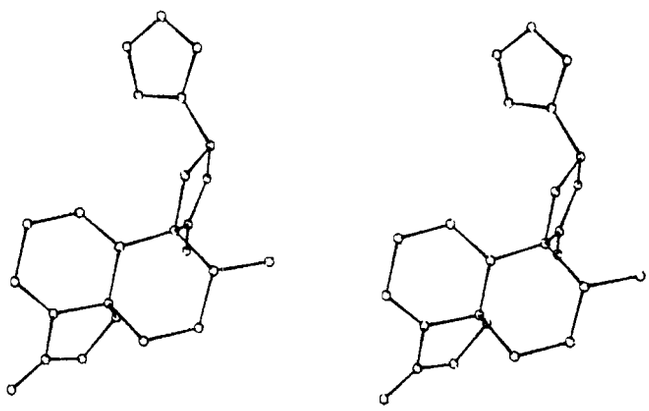


Figure 2. Stereoscopic view of bacchotricuneatin B.

erature.[15,18,21] Final proof for the structures and evidence for the relative stereochemistry at C-12 shown in formulas 1 and 2 were obtained by X-ray analysis of A and B. Stereoscopic views of the two molecules which represent the absolute configurations (see below) are shown in Figures 1 and 2. Bond distances and angles are given in Figures 3 and 4. Tables III and IV, listing fractional coordinates for the nonhydrogen atoms, are available as supplementary material.

The third isomeric lactone, bacchotricuneatin C (3), which had IR bands at 1755 (normal intensity) and 1645 cm^{-1}, contained no hydroxyls (IR spectrum) and no methyl groups (NMR spectrum). Extensive spin decoupling experiments (see Table I) established the presence of partial structure II. Additional features, exclusive of signals associated with the β-substituted furan ring, included a second new AB system centered at 3.45 ppm ($J_{A,B}$ = 9 Hz, H-20) in the characteristic range of ether protons, one of whose components exhibited long range coupling (J = 1.5 Hz) to a proton (H-11a) in a multiplet at 2.17 ppm. Irradiation at this frequency not only sharpened the high-field component (3.3 ppm) of the new AB system but also collapsed a triplet at 4.95 ppm (J = 7 Hz, H-12) to a singlet. The coupling constants exhibited by this triplet were very similar to those of H-12 in 1, though the signal had experienced an upfield shift of 0.5 ppm. Lastly, the NMR spectrum displayed a significant one-proton singlet at 5.22 ppm. Since the four protons responsible for the new AB system, the triplet at 4.95 ppm, and the singlet at 5.22 ppm must be on a carbon linked to the two oxygen atoms of the empirical formula not included in partial structure II, the singlet was surmised to be that of an acetal hydrogen. A biogenetically plausible explanation is that both of the C-8 and C-9 methyl groups required by a presumed clerodane skeleton exist in an oxidized state, one as a primary alcohol

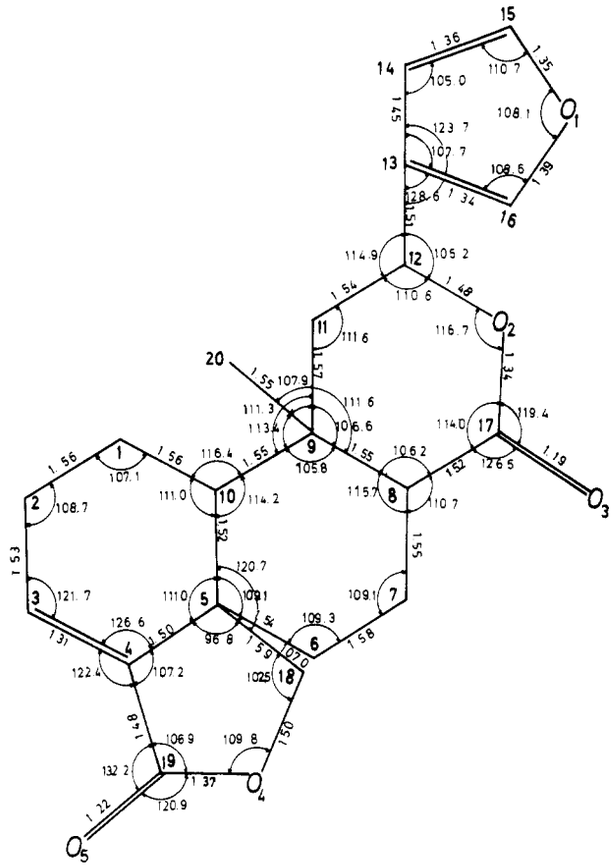


Figure 3. Bond angles and bond distances in bacchotricuneatin A.

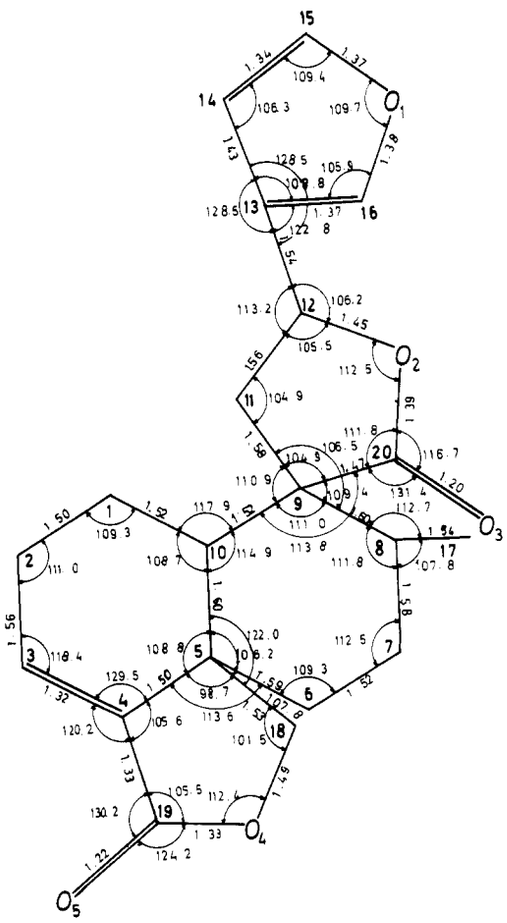


Figure 4. Bond angles and bond distances in bacchotricuneatin B.

and the other as an aldehyde which is involved in acetal formation with the primary alcohol and the customary secondary hydroxyl group on C-12. This would account not only for the empirical formula but also for the upfield shift of H-12.

Since the B proton of the AB system at 3.45 ppm was long range coupled to H-11 and since neither A nor B were coupled vicinally to other protons, the primary alcohol involved in the acetal had to be derived from C-20 and the acetal carbon from C-17. On this basis, stereoformula **3** was the only one which could be constructed with Dreiding models. This also explained one apparent anomaly in the NMR spectrum which showed H-17 as a singlet. From the model the dihedral angle between H-8 and H-17 is ca. 81°, thus leading to a vanishingly small coupling constant. Further chemical and spectroscopic studies were precluded by the small quantity of bacchotricuneatin C.

Bacchotricuneatin D, $C_{20}H_{30}O_3$ (**4a**), was a diol (IR bands at 3500 and 3400 cm^{-1}; no carbonyl absorption), the NMR spectrum of which contained, besides the usual furan peaks, an olefinic multiplet at 5.51 ppm ($W_{1/2}$ = 9 Hz; in this case, obviously not conjugated), two methyl singlets at 1.36 and 1.02 ppm, one methyl doublet at 1.04 ppm, and two signals characteristic of protons on carbons carrying a hydroxyl. A broadened two-proton singlet at 4.12 ppm which shifted downfield (to 4.51 ppm) on acetylation was allylically coupled to the olefinic proton which was in turn coupled to the protons of a methylene group at 1.53 and 2.22 ppm. The presence of a primary allylic alcohol was confirmed by MnO_2 oxidation to a conjugated aldehyde (**5**) [IR band at 1680 cm^{-1}; NMR, -CHO at 9.3 ppm (br), $-CH_2CH{=}CCHO$ at 5.44 ppm (t, J = 4.5 Hz)]. Since all of the evidence again indicated the presence of a clerodane skeleton, the problem of locating the secondary hydroxyl [4.03 ppm ($W_{1/2}$ = 9 Hz)] turned out to be very easy. Irradiation at 1.67 ppm (H-8) collapsed the methyl doublet at 1.04 ppm (H-17) to a singlet and simplified the multiplet at 4.03 ppm to a doublet of doublets (J = 6 and 2.5 Hz), thus indicating axial attachment of the secondary hydroxyl group to C-7. Chemical proof was provided by Jones oxidation of **4b** to a ketone **4c** whose NMR spectrum displayed the signal of H-8 as a quartet (J = 6 Hz) shifted downfield to 2.66 ppm. In addition, the two methyl singlets exhibited significant upfield shifts, indicating the influence of the axial α-oriented C-7 hydroxyl on the two α-oriented axial methyl groups on C-5 and C-9. The ^{13}C NMR spectrum of **4a** (Table II) and the mass spectral fragmentation patterns of **4a** and its derivatives which exhibited a peak at m/e 81 as the predominant fragment containing the furan nucleus were in full accord with the proposed structure.

The absolute configurations of bacchotricuneatin A, B, and C are obviously the same as those of the *ent*-clerodanes from *B. trimera* because of the strong negative Cotton effects of **1**, **2**, and **3** at 240–245 nm due to the n,π^* transition (R band) of the α,β-unsaturated lactone chromophore, the absolute configuration of the *B. trimera* compounds having been deduced in turn[15] from the similarity of the CD curves to that of (−)-methyl hardwickiate[23,24] (**10**). As for bacchotricuneatin D, axial orientation of the C-5 and C-9 methyl groups is compatible with either a *cis*-clerodane skeleton where the C-5 methyl and H-10 are α or a *trans*-clerodane skeleton (C-5 methyl α and H-10 β if the absolute stereochemistry is like that of all other *ent*-clerodanes from *Baccharis* species). However, in view of the established stereochemistry of bacchotricuneatins A–C, a trans ring junction seems much more likely. This conclusion was supported by the CD curve of **4c** which exhibited the relatively strong negative Cotton effect ($\Delta\epsilon$ = −1.86) predicted for a $t3'$-decalone[25] of the depicted absolute configuration with axial methyls on the 3 and 3′ positions and an equatorial alkyl side chain on the 3 position rather than the much weaker positive or possibly weakly negative effect (octant diagram) expected for the corresponding $c3'$eq isomer.

The ether extract of *B. tricuneata* furnished the flavones cirsiliol (6,7-dimethoxy-5,3′4′-trihydroxyflavone; **6b**)[26,27] and cirsimaritin (5,4′-dihydroxy-6,7-dimethoxyflavone; **6a**)[28,29] and the coumarin scopoletin (**7**), which were identified by comparing their spectral properties with those recorded in the literature.

Experimental Section[30]

Extraction of *Baccharis tricuneata*. Dried and powdered above the ground parts of *B. tricuneata* (L.f.) Pers. var. *tricuneata* (weight 3 kg), obtained from Fa. Friedrich G. Zelo, Zweibrücken, as the result of collections in the Andean region near Bogotá, Colombia, in November 1975, were exhaustively extracted in a Soxhlet apparatus with hexane, ether, and methanol (72 h). The hexane extract was evaporated at reduced pressure. The residual crude gum (weight 30 g) was chromatographed in two portions of 15 g each over a column of 1.2 kg of silica gel 60 (Merck; 70–230 mesh ASTM), eluting the column with a 2:3 mixture of n-hexane–ethyl acetate. Fractions of 60 mL were collected and monitored by TLC and Ehrlich's and Dragendorff's reagent. The material from fractions 15–21, 28–49, and 70–93, which showed major spots of bacchotricuneatin A, B and C, and D, respectively, was combined and further purified over silica gel using solvent mixtures of 9:1 CH_2Cl_2–EtOAc for A, B, and C and 1:1 for D. Final purification was achieved by preparative TLC and recrystallization.

Bacchotricuneatin A (**1**) was purified on silica gel (solvent systems: 9:1 CH_2Cl_2–EtOAc, R_f 0.48; 19:1 $CHCl_3$–EtOH, R_f 0.77) and recrystallized from CH_2Cl_2–EtOH (1:4). The slightly greenish prisms (yield 0.270 g) had mp 239–241 °C (with sublimation); $[\alpha]^{25}_D$ −121.4° (c 0.936, $CHCl_3$); UV λ_{max} 210 nm (ϵ 12 100; end absorption), 239 (2350); IR bands (KBr) at 3150, 1500, 870 (furan), 1750 (α,β-unsaturated γ-lactone), 1725 (δ-lactone), and 1645 (double bond) cm^{-1}; CD curve (acetonitrile) $[\theta]_{282}$ 0, $[\theta]_{241}$ −27 000, $[\theta]_{216}$ −6600, $[\theta]_{195}$ −32 000, $[\theta]_{190}$ −31 300 (last reading).

Anal. Calcd for $C_{20}H_{22}O_4$: C, 70.17; H, 6.45; mol wt, 342.1466. Found: C, 70.20; H, 5.04; mol wt (MS), 342.1468.

Other significant peaks in the high-resolution mass spectrum were at m/e (composition, %) 312 (M − CH_2O, 100), 247 ($C_{14}H_{15}O_4$, 3), 231 ($C_{14}H_{15}O_3$, 5), 189 ($C_{12}H_{13}O_2$, 21), 149 ($C_8H_5O_3$, 18), 145 ($C_{11}H_{13}$, 41), 131 ($C_{10}H_{11}$, 27), 95 (C_6H_7O, 98), 95 ($C_5H_3O_2$, 20.8), 94 (C_6H_6O, 90), and 81 (C_5H_5O, 20).

Bacchotricuneatin B (**2**) was purified on silica gel (solvent systems: 44:1 CH_2Cl_2–EtOAc, R_f 0.22; $CHCl_3$–EtOH, R_f 0.82) and recrystallized from CH_2Cl_2–hexane (1:5). The colorless crystals (0.16 g) had mp 191–192 °C dec; $[\alpha]^{25}_D$ −93.3° (c 0.932, $CHCl_3$); UV λ_{max} 210 nm (ϵ 8930; end absorption), 240 (1540); IR bands (KBr) at 3160, 1490, 878 (furan), 1740 (two γ-lactones), and 1640 (double bond) cm^{-1}; CD curve (acetonitrile) $[\theta]_{288}$ 0, $[\theta]_{245}$ −17 600, $[\theta]_{227}$ 0, $[\theta]_{215}$ 10 600, $[\theta]_{204}$ 0.

Anal. Calcd for $C_{20}H_{22}O_5$: C, 70.17; H, 6.45; mol wt, 342.1466. Found: C, 70.20; H, 5.98; mol wt (MS), 342.1474.

Other significant peaks in the high-resolution mass spectrum were at m/e (composition, %) 312 (M − CH_2O, 100), 284 ($C_{18}H_{20}O_3$, 12), 267 ($C_{18}H_{19}O_2$, 9.7), 239 ($C_{17}H_{19}O$, 9.6), 231 ($C_{14}H_{15}O_3$, 1.3), 218 ($C_{13}H_{14}O_3$, 12.5), 173 ($C_{12}H_{18}O$, 6.7), 145 ($C_{11}H_{13}$, 17), 95 (C_6H_7O, 40), 94 (C_6H_6O, 32), and 81 (C_5H_5O, 14).

Bacchotricuneatin C was purified by preparative TLC in 24:1 $CHCl_3$–EtOH (R_f 0.67) and 9:1 CH_2Cl_2–EtOAc (R_f 0.41). Recrystallization from CH_2Cl_2–EtOH (1:2) furnished colorless plates with mp 188–190 °C (yield 4 mg): UV λ_{max} 210 nm (ϵ 14 500; end absorption), 241 (2310); IR bands (KBr) at 3140, 1505, 880 (furan), 1755 (α,β-unsaturated γ-lactone), and 1645 (double bond) cm^{-1}; CD curve (MeOH) $[\theta]_{275}$ 0, $[\theta]_{241}$ −26 000, $[\theta]_{230}$ −14 000 (last reading).

Anal. Calcd for $C_{20}H_{22}O_5$: mol wt, 342.1466. Found: mol wt (MS), 342.1465.

Significant peaks in the low-resolution mass spectrum were at m/e (%) 342 (M^+, 1.95), 312 (M^+ − 30, 0.47), 261 (M^+ − 81, 0.73), 248 (1.6), 145 (4.7), 95 (78), 94 (43), 81 (82), and 71 (100).

The Ehrlich positive material of column 4 (1:1 CH_2Cl_2–EtOAc) was purified by preparative TLC using 19:1 $CHCl_3$–EtOH (R_f 0.38) and recrystallized from EtOAc–hexane (1:1). The yield of bacchotricuneatin D, mp 109–111 °C, was 104 mg of colorless needles: $[\alpha]^{25}_D$ −7.41° (c 0.582, $CHCl_3$); UV λ_{max}, strong end absorption beginning at 217 nm; IR bands (KBr) at 3500, 3400 (OH), 3090, 1490, 870 (furan), and 1600 (double bond) cm^{-1}.

Anal. Calcd for $C_{20}H_{30}O_3$: C, 75.47; H, 9.43; mol wt, 318.2195.

Found: C, 75.29; H, 9.37; mol wt (MS), 318.2187.

Other significant peaks in the high-resolution mass spectrum were at *m/e* (composition, %) 300 ($M^+ - H_2O$, 1.5), 288 ($M^+ - CH_2O$, 32.4), 204 ($C_{14}H_{19}O$, 19), 191 ($C_{13}H_{19}O$, 21.8), 187 ($C_{14}H_{19}$, 17.3), 145 ($C_{11}H_{13}$, 20.5), 95 (C_6H_7O, 12.9), 94 (C_6H_6O, 10.8), 93 (C_7H_9, 100), and 81 (C_5H_5O, 66).

The ether extract of *B. tricuneata*, after being stored for 10 days at −10 °C, gave a precipitate (6 g) which gave a positive test for flavonoids. The crude material was chromatographed over silica gel, eluting the column in the following order: fraction 1, petroleum ether; fraction 2, benzene; fraction 3, $CHCl_3$; fraction 4, MeOH–$CHCl_3$ (1:9); fraction 5, MeOH–$CHCl_3$ (1:4); fraction 6, MeOH–$CHCl_3$ (1:1). Fractions 4–6 were combined, concentrated, and further purified by preparative TLC over silica gel, (125:72:3 benzene–acetic acid–water). There was obtained 45 mg of cirsiliol (**6b**), mp 273–275 °C, after recrystallization from MeOH (lit.[26,27] mp 278 °C): mol wt (MS), 330 (fragments at *m/e* 181 and 135); UV λ_{max} (MeOH) 344, 272, 255 nm; UV λ_{max} (MeOH–$AlCl_3$) 436, 339 sh, 309 sh, 275 nm; UV λ_{max} (MeOH–NaOAc) 405, 269 nm; UV λ_{max} (MeOH–NaOAc–H_3BO_3) 371, 261 nm; NMR (60 MHz, Me_2SO-d_6) 3.79 (C-6 OMe), 3.95 (C-7 OMe), 6.70 (H-8), 6.83 (H-3), 6.98 (br, H-5′), 7.46 (m, H-2′ and H-6′) ppm.

The yield of cirsimaritin (**6a**) was 18 mg: mp (from ethanol) 254–256 °C (lit.[28,29] mp 255–257 °C); mol wt (MS), 314 (fragments at *m/e* 181 and 119); UV λ_{max} (MeOH) 333, 274, 213 nm; UV λ_{max} (MeOH–$AlCl_3$) 364, 300 sh, 289 sh nm; UV λ_{max} (MeOH–$AlCl_3$–HCl) 356, 300 sh, 285 nm; UV λ_{max} (MeOH–NaOMe) 358 br, 303 sh, 274 nm; UV λ_{max} (MeOH–NaOAc) 388, 298 sh, 272 nm; NMR (60 MHz, Me_2SO-d_6) 3.83 (C-6 OMe), 4.03 (C-7 OMe), 6.87 (H-3), 6.98 (H-8), 7.08 (d, H-3′ and H-5′), 8.11 (d, H-2′ and H-6′) ppm.

The ether extract remaining after removal of the precipitate was evaporated, and the residue was extracted thoroughly with $CHCl_3$–H_2O. The $CHCl_3$ fraction, enriched in scopoletin, was chromatographed over silica gel eluting with 7:3 benzene–acetone. The fractions containing scopoletin were combined and recrystallized from $CHCl_3$: yield of **7**, 57 mg; mp 205 °C (lit.[31] mp 204–205 °C); the mixed melting point with an authentic sample was undepressed; UV λ_{max} (MeOH) 229, 253, 296, 345 nm.

Anal. Calcd for $C_{10}H_8O$: C, 62.50; H, 4.20. Found: C, 62.48; H, 4.27.

Ehrlich Reaction. A TLC plate of bacchotricuneatin A, B, and C showed a rose red color; one of D showed a violet color when sprayed with a solution of *p*-dimethylaminobenzaldehyde (1 g) in MeOH–36% HCl (75:25 mL).

Selective Monoacetylation of 4a. A solution of 0.08 g of **4a** in 0.5 mL of pyridine and 0.5 mL of acetic anhydride was allowed to stand at 10 °C for 7 min and then was worked up in the usual manner. The product, 0.039 g of **4b**, was purified by preparative TLC (10:1 $CHCl_3$–EtOH), but it could not be induced to crystallize. The UV spectrum exhibited end absorption only; IR bands at 3480 (OH), 1730 (acetate), 3120, 1495, 850 (furan), and 1630 (double bond) cm^{-1}; low-resolution mass spectrum, *m/e* 360 (M^+, 0.04), 300 (M − HOAc, 4), 266 (4.1), 145 (16.8), 95 (24), 91 (39), 81 (33).

Oxidation of 4b. To an ice cold solution of 25 mg of **4b** in 5 mL of acetone was added 3 drops of Jones reagent with stirring. Stirring was continued for 5 min, excess oxidant was destroyed by adding 10 drops of MeOH, the solvents were removed at reduced pressure, and the residue was diluted with ice water and extracted with $CHCl_3$. The washed and dried extract was evaporated, and the residue was purified by preparative TLC (24:1 $CHCl_3$–EtOH) to yield 13 mg of gummy ketone **4c**: UV λ_{max} 273 nm (ϵ 38.5); IR bands (film) at 3130, 1500, 850 (furan), 1735 (acetate), 1710 (ketone), and 1630 (double bond) cm^{-1}; CD curve (MeOH, *c* 0.409) $[\theta]_{318}$ 0, $[\theta]_{291}$ −6150, $[\theta]_{253}$ 0.

Anal. Calcd for $C_{22}H_{30}O_4$: mol wt, 358.2143. Found: mol wt (MS), 358.2173.

Other significant peaks in the high-resolution mass spectrum were at *m/e* (composition, %) 298 ($C_{20}H_{26}O_2$, 14.1), 263 ($C_{16}H_{23}O_3$, 8.6), 203 ($C_{14}H_{18}O$, 100), 145 ($C_{11}H_{13}$, 11.6), 95 (C_6H_7O, 41.3), 94 (C_6H_6O, 5.7), and 81 (C_5H_5O, 56.4).

MnO_2 Oxidation of 4a. A solution of 0.02 g of **4a** in 7 mL of $CHCl_3$ was stirred with 0.08 g of freshly prepared MnO_2 at room temperature, the reaction being monitored by TLC. After 8 h when starting material had disappeared, the mixture was filtered and the residue thoroughly washed with $CHCl_3$. The combined filtrates and washings were evaporated. The residue was purified by preparative TLC (19:1 $CHCl_3$–EtOH) and yielded 12 mg of gummy **5**: UV λ_{max} (MeOH) 217 nm (ϵ 10 800); IR bands (film) at 3135, 1500, 850 (furan), 3480 (OH), and 1680 and 1620 (α,β-unsaturated aldehyde) cm^{-1}; mass spectral peaks at *m/e* 316 (M^+, 18.2), 301 (M − CH_3, 4.1), 221 (24), 219 (100), 145 (14.6), 95 (42.7), 94 (11.5), 93 (39.8), and 81 (86.8).

Anal. Calcd for $C_{20}H_{28}O_3$: mol wt, 316.2037. Found: mol wt (MS), 316.2018.

X-Ray Analysis of Bacchotricuneatin A. The cell constants were *a* = 12.454 Å, *b* = 11.043 Å, and *c* = 12.345 Å and the space group was orthorhombic $P2_12_12_1$ with four molecules in the unit cell, as determined by systematic absences on Weissenberg and precession photographs. The density, measured by flotation in KI/H_2O, was 1.345 g/cm^3 and agreed with the calculated value of 1.338 g/cm^3. Single crystal data up to $\sin\theta/\lambda = 0.59$ $Å^{-1}$ were collected on an automated Siemens diffractometer with Ni-filtered Cu Kα radiation (λ = 1.5418 Å). A total of 1624 independent reflections were measured, out of which 1545 were recorded as observed [$>2\sigma(I)$]. The data collection technique used was $\theta - 2\theta$ scanning with symmetrical 2° scan ranges and a scan speed of 1°/min. Data were scaled by Wilson statistics.

The structure was solved by direct methods using MULTAN.[32] Three origin and five starting reflections were selected (one for the enantiomorph) and gave 128 possible phase sets. An *E* map with the best of these, by means of "combined figure of merit", using 175 *E* gave positions for 24 of the 25 nonhydrogen atoms. A Fourier with the complete data set using the X-Ray System[33] revealed the last atom.

Refinement to convergence was carried out using a full matrix least-squares approach. A final *R* factor of 7.5% resulted, based on observed reflections. The function minimized was $\Sigma w\Delta^2$. Figure 1 is a stereoscopic view of the molecule; bond lengths and angles are given in Figure 3. Fractional coordination of the nonhydrogen atoms is listed in Table III of the supplementary material.

X-Ray Analysis of Bacchotricuneatin B. Crystal data were determined by preliminary precession and Weissenberg photographs and gave *a* = 21.595 Å, *b* = 6.594 Å, and *c* = 12.011 Å in the orthorhombic space group $P2_12_12_1$ with four molecules in the unit cell. The density, measured by flotation in KI/H_2O, was 1.359 g/cm^3 compared with a calculated value of 1.329 g/cm^3. Intensity measurements were made in the manner described in the previous section on a crystal of size 0.6 × 0.2 × 0.2 mm; 1683 reflections were measured up to 2θ = 130°, of which 1314 were regarded as observed. One reference reflection monitored after every 20 measurements showed no significant change in intensity. No absorption correction was applied. Data were scaled by Wilson statistics in the usual way.

The structure was solved using MULTAN. A first attempt to find an appropriate phase set for the 400 biggest *E*'s with three origin and five starting reflections gave *E* maps which could not be interpreted. Reduction of the number of *E*'s to 200, according to a proposal by Lessinger[34] by means of which the ratio of Σ_2 relations and the number of *E* are improved, led to the correction solution with the same origin and only three more starting reflections. An *E* map using these 200 phases gave the position of all 25 nonhydrogen atoms.

Three isotropic refinement cycles followed by three cycles with anisotropic temperature vibrations (3) converged at a final *R* of 9.2%, based on observed reflections, as described above. A stereoscopic view of the molecule is shown in Figure 2; bond distances and angles are given in Figure 4. Fractional coordinates are listed in Table IV of the supplementary material.

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Registry No.—**1**, 65596-25-0; **2**, 65596-26-1; **3**, 66563-30-2; **4a**, 66563-31-3; **4b**, 66563-32-4; **4c**, 66563-33-5; **5**, 66563-34-6; **6a**, 6601-62-3; **6b**, 34334-69-5; **7**, 92-61-5.

Supplementary Material Available: Tables III and IV listing fractional coordinates of **1** and **2** (2 pages). Ordering information is given on any current masthead page.

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Generation of Carbethoxynitrene by α Elimination and Its Reactions with Olefins under Two-Phase Conditions

Manabu Senō,* Tomiyuki Namba, and Hideo Kise

Institute of Industrial Science, University of Tokyo, 7-22 Roppongi, Minato-ku, Tokyo, Japan

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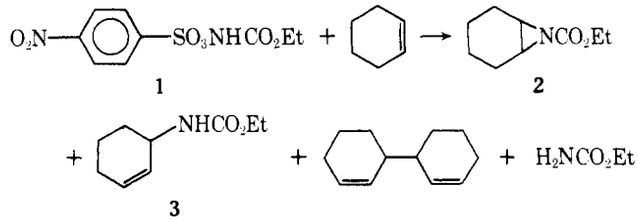
The base decomposition of ethyl *p*-nitrobenzenesulfonoxycarbamate (1) in organic–aqueous two-phase systems in the presence of cyclohexene and quaternary ammonium or phosphonium halides afforded 7-carbethoxy-7-azabicyclo[4.1.0]heptane (**2**), ethyl 3-cyclohexenylcarbamate (**3**), 3,3′-bicyclohexenyl, and ethyl carbamate. The reactivity of **1** and the product selectivity (addition/insertion ratio) are quite analogous to those reported for homogeneous reactions of **1** with cyclohexene, indicating the generation of a common intermediate of carbethoxynitrene by α elimination of **1**. The reactions of **1** with *cis*- and *trans*-4-methyl-2-pentenes were also studied, and the results were interpreted in view of the electronic state of the nitrene.

The reactions between substances located separately in an organic phase and an aqueous phase are frequently accelerated by catalytic amounts of quaternary ammonium or phosphonium salts.[1] These systems are of particular advantage for the reactions which proceed via unstable intermediates such as carbanions,[2] ylides,[3] and carbenes[4] since most of these reactions have been considered to require aprotic solvents and strictly anhydrous conditions. Two-phase reactions by phase-transfer catalysts enable us to carry out these organic reactions using aqueous inorganic base solutions and are considered to be of great practical value.

The present study is concerned with the application of the two-phase reaction technique to the generation of carbethoxynitrene by α elimination and its reactions with olefins. Both the reactivity and selectivity of the nitrene generated in these systems will be examined in view of the effects of the aqueous phase and quaternary salts on the electronic state of the nitrene.

Results and Discussion

It has been reported by Lwowski and his co-workers that the treatment of ethyl *p*-nitrobenzenesulfonoxycarbamate (**1**) with triethylamine gives rise to carbethoxynitrene which is postulated to be of the singlet state.[5] We carried out this reaction in two-phase systems which consist of aqueous sodium bicarbonate solutions and dichloromethane solutions of olefins in the presence of a catalytic amount of quaternary ammonium or phosphonium halides. In the case of cyclohexene, both a presumed addition product of carbethoxynitrene to the C=C double bond, 7-carbethoxy-7-azabicyclo[4.1.0]heptane (**2**), and an insertion product into the C–H bond, ethyl 3-cyclohexenylcarbamate (**3**), were obtained together with small amounts of 3,3′-bicyclohexenyl and ethyl carbamate.



1 2 3

All of these compounds are common products obtained from the photodecomposition of ethyl azidoformate and from the homogeneous α elimination of **1** by triethylamine in the presence of cyclohexene.[5a,b] This indicates the formation of a common intermediate, carbethoxynitrene, also in the present two-phase system, although nitrenes have been con-

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