Isolation of Two Phenylbutadiene Dimers and One Monomeric 4-Phenylbut-3-ene from *Zingiber cassumunar* (roxb.)

Hildegard Dinter and Rudolf Hänsel

Institut für Pharmakognosie und Phytochemie, Königin-Luise-Straße 2–4, 1000 Berlin 33

Andrew Pelter

University College of Swansea, Department of Chemistry, Singleton Park, Swansea, SA 2 8 PP

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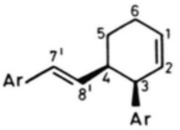
Two arylbutadiene dimers of the 3-aryl-4-styrylcyclohexene series together with a novel C_6-C_4 monomer (2-(3,4-dimethoxystyryl)ethanol) have been isolated from *Zingiber cassumunar.* Due to their co-occurrence and the chemical similarity of one portion of the molecules, a possible biosynthetic relationship between the cyclohexene dimers and the phenylnaphthaquinones of *Z. cassumunar,* based on Diels-Alder reactions, is suggested.

Continuing an earlier investigation [1] of a crude toluene-extract from wild ginger (rhizome of *Zingiber cassumunar* (roxb.) two vanillin-H_2SO_4-positive spots were located on tlc. Monitoring by tlc, we isolated these two cassumunar-substances 1 and 2 (CS 1 and CS 2) [2] by extensive column chromatography on silica gel in low yields (1 kg crude drug gave 40 mg of CS 1 and 20 mg of CS 2 respectively).

CS 1 crystallises as colourless needles, m. p. 130 to 131 °C from methanol. It has the molecular formula $^{12}C_{26}H_{32}O_6$ (M^+, 440.2200), $\lambda_{\max}$ ($CDCl_3$), 261 (4.29), 298 (3.96), 315 nm (3.94), $\nu_{\max}$ (KBr), 1610, 970 and 691 cm^{-1}. Under electron bombardment the molecule undergoes a reverse Diels-Alder reaction to give the base peak at m/e 220.

CS 2 crystallises as white needles m. p. 98 – 101 °C from methanol. It has the molecular formula $^{12}C_{24}H_{28}O_4$ (380.1987). $\lambda_{\max}$ ($CDCl_3$) 240 (4.13), 267 (4.23), 273 (4.25), 289 (4.02), 303 (3.83), 3.16 (3.53), $\nu_{\max}$ (KBr), 1600, 960, 685 cm^{-1}. As with CS 1, a reverse Diels-Alder reaction occurs in the mass spectrometer to give the base peak at m/e 190.

The ^1H NMR of both substances were highly informative and enabled us to define them as *cis*-3-aryl-4-styrylcyclohexenes (see **1** and **2**).



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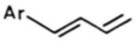

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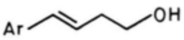

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(1) and (3), Ar = 2,4,5-trimethoxyphenyl

(2),(4) and (5), Ar = 3,4-dimethoxyphenyl

Extensive decoupling of the aliphatic protons allowed the assignments shown in Table I to be made. In particular decoupling between H-2 and H-3 allowed $J_{3,4}$ to be determined as 5 Hz for CS 2, and so the substituents at C-3 and C-4 must be *cis.* By analogy the same assignment was made for CS 1.

In CS 1 it was clear that the aromatic protons on each ring were *para* to each other, but this does not serve to completely define the substitution pattern of the ring. No information regarding the substitution pattern of the two methoxyl groups in each ring of CS 2 could be obtained from the ^1H NMR spectrum, but the ^{13}C NMR spectra served to settle both points and to characterise CS 1 as **1** and CS 2 as **2**.

The calculated values are those based on incremental shifts for simple aromatic rings [3], which are models of limited utility. Nevertheless, only the 2,4,5-trimethoxyphenyl substitution pattern is satisfactory for CS 1 and only 3,4-dimethoxyphenyl ring satisfies the requirements of CS 2 which are therefore defined as **1** and **2** respectively. The similarity of the aromatic carbons in the ^{13}C NMR spectra of CS 2 and the unambiguously assigned monomer [5] (Table III) serves also to define clearly the substitution pattern of CS 2 and underline the somewhat limited use of models for this series. It is interesting to note that the 2′(2″)-OMe groups cause a significant change in the chemical shifts of C-3 and C-4 in CS 1 as compared with CS 2. CS 1 is identical with alflabene, recently isolated from *Alpinia flabellata* [4] and we call CS 2, cassumunene *.

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* Following completion of this ms it came to our attention that, very recently, both CS 1 and CS 2 had been isolated from *Z. cassumunar* and characterised by X-ray analysis [5]. Our proposed structures agree completely with those found by X-ray crystallography.

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Table I. ^1H NMR of CS1 and CS2 [a].

Proton	CS1 Undecoupled	CS1 Decoupled at proton	CS1 Simplified signal	CS2 Undecoupled	CS2 Simplified signal
H-1 (1H)	5.6 – 5.98 m	H-6	5.91, d, $J_{12} = 10$ Hz	5.72 – 6.1 m	5.95, d, $J_{12} = 11$ Hz
H-2 (1H)			5.72, dd, $J_{21} = 10$ Hz $J_{23} = 4$ Hz		5.78, dd, $J_{21} = 11$ Hz $J_{23} = 7$ Hz
H-3 (1H)	4.08, m	H-2 H-4	4.08, simplif. m 4.08, simplif. m	3.46, m	3.46, d, $J_{34} = 5$ Hz 3.46, simplif. m
H-4 (1H)	2.76, m	H-5	2.76, simplif. m	2.66, m	2.66, simplif. m
H-5 (2H)	1.76, m	H-4	1.76, simplif. m	1.62, m	1.62, simplif. m
H-6 (2H)	2.18, m	H-5	2.18, simplif. m	2.19, m	2.19, simplif. m
H-8′ (1H)	5.74, dd $J_{8'7'} = 16$ Hz $J_{8'4} = 8$ Hz	H-4	5.74, simplif. m	5.53, dd $J_{8'7'} = 16$ Hz $J_{8'4} = 8$ Hz	5.53, d. $J_{8'7'} = 16$ Hz
H-7′ (1H)	6.40, d $J_{7'8'} = 16$ Hz			6.20, d $J_{7'8'} = 16$ Hz	
Aromatic protons	6.38, s, (1H) 6.4, s. (1H) 6.66, s, (1H) 6.71, s, (1H)			6.62 – 6.72 m, (6H)	
OMe	3.62, s, (3H) 3.66, s, (3H) 3.72, s, (6H) 3.78, s, (6H)			3.69, s, (3H) 3.76, s, (3H) 3.78, s, (6H)	

[a] All spectra run in $CDCl_3$, chemical shifts measured in δ.

Neither substance shows any Cotton effects in the CD and they must therefore be racemic. Theoretically a dimerisation of **3** by a Diels-Alder reaction could lead to **1**, and similar dimerisation of **4** could yield **2**. It was therefore of the greatest interest that the monomer **5**, closely related to **4** could be isolated in considerably greater quantity than either **1** or **2** *i. e.* **1**, 40 mg, **2** 20 mg and **5** 1000 mg.

Compound **5** at room temperature is a colourless oil with molecular formula $^{12}C_{12}H_{16}O_3$ (M^+, 208.1099), base peak 177; λ_{max} ($CHCl_3$), 260 (4.15), 264 (4.14), 290 (3.66), 300 nm (3.62), ν_{max} 3450, 1600, 965 cm^{-1}.

Oxidation of compound **5** with the appropriate reagents gave veratric acid and veratraldehyde. This taken together with the ^{13}C and ^1H NMR spectra, assigned as in Table III and **6** serve to unambiguously define structure **5**. As noted previously the correspondence in the ^{13}C NMR spectra between CS 2 and **5** serve to confirm the structure of CS 2.

In view of our isolation of cassumunaquinones 2 **7** and 1 **8** together with alflabene **1** and cassumunene **2** it is possible to imagine a hypothetical biosynthetic scheme (Fig. 1) which serves to unify the biosyn-

Table II. ^{13}C NMR of cassumunar substances 1 and 2 [a, b, c, d]

Carbon atom	CS1	Calcd. value	CS2	Calcd. value
1	128.1 ⁺		128.0 ⁺	
2	131.9		132.4	
3	41.6		45.8	
4	37.3		42.6	
5	24.1		24.4	
6	25.5		24.8	
8′	129.6 ⁺		129.2 ⁺	
7′	122.7		122.0	
1′	122.6	116.9	131.2	131.3
2′	151.8	151.2	108.8	113.1
3′	98.4	100.9	149.0 *	145.7
4′	148.8 *	146.0	148.2 *	145.0
5′	143.4	138.0	113.8	115.3
6′	110.1	114.1	118.8	119.8
1″	119.7		133.9	
2″	150.9		110.5	
3″	97.4		148.3 *	
4″	148.0 *		147.6 *	
5″	142.5		111.3	
6″	115.2		128.6 ⁺	

[a] All spectra in $CDCl_3$, chemical shifts measured in p.p.m. downfield from TMS. [b] All assignments supported by the multiplicity of the signal in the off-resonance spectrum. [c] Identical signs indicate interchangeable assignments. [d] 1′ – 6′ refer to the styryl aromatic ring, 1″ – 6″ refer to the aromatic ring attached to C-3.

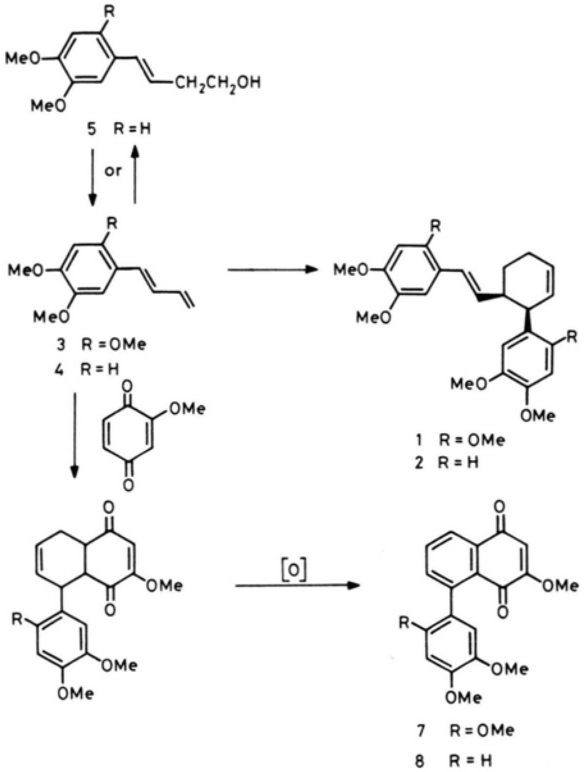
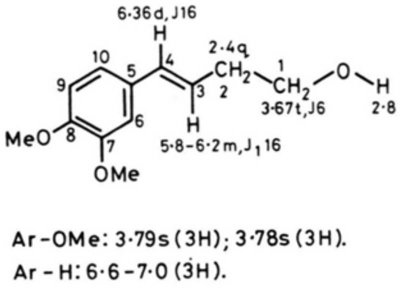


Fig. 1. Hypothetical biosynthetic scheme.

Table III. ^{13}C NMR spectra of monomer **5** and CS2.

	Monomer 5		CS2
C-1	61.9		–
C-2	36.3		–
C-3	131.9	C-8′	129.2
C-4	124.7	C-7′	122.0
C-5	130.7	C-1′	131.2
C-6	108.9	C-2′	108.8
C-7	149.1	C-3′	149.0
C-8	148.5	C-4′	148.2
C-9	111.4	C-5′	113.8
C-10	119.1	C-6′	118.8

Signal at δ 3.67 moves to δ 4.11 on acetylation.



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Scheme. Signal at δ 3.67 moves toδ 4.11 on acetylation.

thesis of those compounds we have isolated. Clearly a monomer corresponding to **5** but with R = OMe, (Fig. 1) is missing and we are currently searching for this compound.

The question as to whether or not the dimers and the quinones are "natural products" cannot be satisfactorily answered. Our conditions of extraction and purification were mild but the amounts isolated were small compared with monomer **5**, and clearly a small amount of Diels-Alder reaction cannot be excluded. However this might also happen in the plant, either by enzymic or non-enzymic processes.

[1] H. Dinter, R. Hänsel, and A. Pelter, Z. Naturforsch. **35 c,** 154 (1980).
[2] H. Dinter, Thesis, Free University Berlin 1979 (where details on the isolation procedure are given).
[3] F. W. Wehrli and T. Wirthlin, Interpretations of ^{13}C NMR Spectra, Heyden and Sons, London 1978.
[4] J. Mori and Y. Nakachi, Tetrahedron Letters, **1978,** 2297.
[5] T. Amakayakul *et al.*, Austral J. Chem. **32,** 71 (1979).