

Specionin, an Iridoid Insect Antifeedant from *Catalpa speciosa*

Conway C. Chang and Koji Nakanishi*

Department of Chemistry, Columbia University, New York, N.Y. 10027, U.S.A.

The leaves of *Catalpa speciosa* have yielded the iridoid specionin (1) which has antifeedant properties against spruce budworm.

The Eastern spruce budworm which infests North American fir and spruce forests in May inflicts huge damage to the lumber industry. In order to find an effective antifeedant against this pest, leaves of forty different trees that are not attacked by the worms were collected and extracted with EtOH. The extracts were then screened and fractionated by antifeedant assays using budworms fed on an artificial diet with or without the extract. This has led to the isolation of specionin (1) from the leaves of *Catalpa speciosa* Warder (Bignoniaceae).

The extract in aqueous MeOH was extracted with hexane, CH₂Cl₂, and EtOAc. The active EtOAc extract was evaporated, and the residue in MeOH was submitted to Sephadex LH-20 and flash chromatography. Final purification was accomplished by preparative Whatman Partisil M-9 (6:1 v/v, cyclohexane-Pr¹OH). From 9 g of EtOH extract there was obtained 7 mg of specionin (1).

The desorption chemical ionization mass spectrum¹ (NH₃ reactant gas) exhibited quasi-molecular peaks at m/z 395 {[*M* + H]⁺} and 412 {[*M* + H + NH₃]⁺}. Fragmentation peaks at m/z 349 {[*M* - 45]⁺} and 303 {[*M* - 45 - 46]⁺} were interpreted as losses of ethoxy and ethanol moieties. The presence of a hydroxybenzoate moiety was indicated by λ_{max} (MeOH) 254 nm (ε 1 140) and supported by the m/z 121 mass spectral peak.

The ¹³C n.m.r. data, especially the *J*-modulated spin echo spectra,² showed (1) to contain two methyl groups (δ 15.6 and 15.5), one methylene (30.4, C-4), two methine (34.2 and 41.2, C-5 and C-9), three OCH₂ (61.2, 64.0, and 64.8, C-7 and CH₂O of the two ethoxy groups), two OCH (61.4 and 80.7, C-10 and C-6), one C-O (quaternary) (67.3, C-8), two hemiacetal CH (94.8 and 97.7, C-3 and C-1), four unsubstituted aromatic carbons (116.3, 116.3, 132.8, and 132.8, C-3', C-5', C-2' and C-6'), two substituted aromatic carbons (121.5 and 164.0, C-1' and C-4'), and one carbonyl carbon (168.2 p.p.m.). A total of 20 carbon resonances were observed.

The ¹H n.m.r. data shown in Table 1 (in CD₃OD) were derived from extensive decoupling experiments and two-dimensional spectroscopy.³ The two nonequivalent methylene hydrogens at δ 3.50 and 3.85 are coupled geminally and further to the methyl groups at δ 1.17 and 1.21.

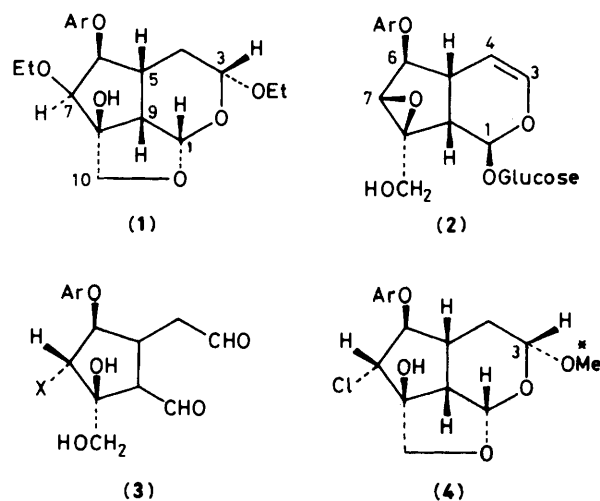


Table 1. ¹H N.m.r. data for specionin (1), 250 MHz, CDCl₃, δ and *J*/Hz.

1-H	5.10, d, 4.1	3-OCH _a	3.50, dq
3-H	4.90, dd, 2.8, 6.3	3-OCH _b	3.85, dq
4-H _a	1.81, ddd, 6.3, 7.4, 13.6	7-OCH _a	3.50, dq
4-H _b	1.94, ddd, 2.8, 5.2, 13.6	7-OCH _b	3.85, dq
5-H	2.34, dddd, 5.2, 7.4, 8.1, 8.5	Me(OCH ₂ CH _a)	1.17, dd, 7.0, 7.0
			1.21, dd, 7.0, 7.0
6-H	5.32, dd, 1.1, 8.5	3'-H, 5'-H	6.83, d, 7.8
7-H	3.60, d, 1.1	2'-H, 6'-H	7.89, d, 7.8
9-H	2.80, dd, 4.1, 8.1		
10-H _a	3.55, d, 12.5		
10-H _b	4.05, d, 12.5		

Nuclear Overhauser effect (n.O.e.) difference spectra⁴ were measured to determine the relative stereochemistry. Irradiation of 6-H (δ 5.32) caused a 16% n.O.e. at the 7-H, while no n.O.e. was observed for 5-H. Irradiation of the 5-H peak (δ 2.34) exerted n.O.e.'s of 25 on 9-H, 6 on 1-H, and 14% on 4-H_a, but no effect on 6-H. Irradiation of 9-H gave 20 and 25% n.O.e. for 5-H and 1-H, respectively, while irradiation of 1-H at δ 5.20 led to an 11% n.O.e. for 9-H.

A close structural relationship is seen between specionin (1) and the well known iridoid glucoside catalposide (2)⁵ which has also been found in the same aqueous EtOH extract of the *Catalpa* leaves. We thus assign the same configurations at C-5 and C-9 for both (1) and (2), the absolute configuration of (2) being established by chemical degradations.^{†6}

The genesis of (1) is not clear. Since it was suspected that (1) could be an artifact derived from (2) via a hypothetical intermediate of type (3)[‡] during EtOH extraction, catalposide (2) was treated with ¹³CH₃OH-HCl. This yielded the chloro-derivative (4) as characterized by spectroscopic data including the δ 5.15 signal for 3-H which appeared as a ddd signal, *J* 6.5, 6.5, and 3.85 Hz, the latter *J* being due to its extra coupling with O¹³CH₃. Whatever the origin of specionin may be, its spruce budworm antifeedant activity should be noted. Namely, the activity level is ca. 50–100 p.p.m., and unlike many other antifeedants which although potent have too complex a structure to be synthesized, e.g. azadirachtin⁷ (one of the most active antifeedants), the structure of this iridoid is quite simple.

We are grateful to Drs. W. A. Côté, III and L. S. Press (International Paper Company) and Drs. M. Houseweart and D. Jennings (University of Maine) for suggestions and dis-

† We found that the original coupling constant assignments between 5-H/6-H and 6-H/7-H had to be interchanged, thus *J*_{5,6} is 8.8 (not 1.0) and *J*_{6,7} 1.0 (not 8.8) Hz.

‡ A leaving group X is hypothesized to account for the same C-7 configuration in (1) and (2).

cussions. The studies were supported by grants from N.I.H. and the International Paper Company.

Received, 28th February 1983; Com. 265

References

- 1 D. F. Hunt, J. Shabanowitz, F. K. Botz, and D. A. Brent, *Anal. Chem.*, 1977, **49**, 1160; K. Hostettmann, J. Dumas, and M. Hardy, *Helv. Chim. Acta*, 1981, **64**, 297.
- 2 G. A. Morris and R. Freeman, *J. Am. Chem. Soc.*, 1979, **101**, 761; D. M. Doddrell, D. T. Pegg, W. Brooks, and M. R. Bendall, *J. Am. Chem. Soc.*, 1981, **103**, 727; C. LeCocq and T. Y. Lallemand, *J. Chem. Soc., Chem. Commun.*, 1981, 150; D. J. Cookson and B. E. Smith, *Org. Magn. Reson.*, 1981, **16**, 111.
- 3 W. P. Aue, J. Karhan, and R. R. Ernst, *J. Chem. Phys.*, 1976, **64**, 4226; K. Wuthrich, K. Nagayama, and R. R. Ernst, *Trends Biochem. Sci.*, 1980, 178; L. D. Hall and J. K. M. Sanders, *J. Am. Chem. Soc.*, 1980, **102**, 5703.
- 4 J. C. Lindon and A. G. Ferrige, *Prog. Nucl. Magn. Reson. Spectrosc.*, 1980, **14**, 27.
- 5 E. Claassen, *Am. Chem. J.*, 1888, **10**, 328; H. Clin, G. Tanret, and M. M. Chollet, *C.R. Acad. Sci.*, 1943, **216**, 677; M. M. Chollet, *Bull. Soc. Chim. Biol.*, 1946, **28**, 668.
- 6 J. M. Bobbitt, D. W. Spiggle, S. Mahboob, W. von Philipsborn, and H. Schmid, *Tetrahedron Lett.*, 1962, 321; *J. Org. Chem.*, 1966, **31**, 500; J. M. Bobbitt, D. E. Kiely, A. Y. Lam, and E. I. Snyder, *J. Org. Chem.*, 1967, **32**, 1459; W. H. Lunn, D. W. Edward, and J. T. Edward, *Can. J. Chem.*, 1962, **40**, 104; *Chem. Ind. (London)*, 1961, 1488.
- 7 P. Zanno, I. Miura, K. Nakanishi, and D. Elder, *J. Am. Chem. Soc.*, 1975, **97**, 1975.