

Crystal Structure of Hydroxypelenolide *p*-Bromobenzoate

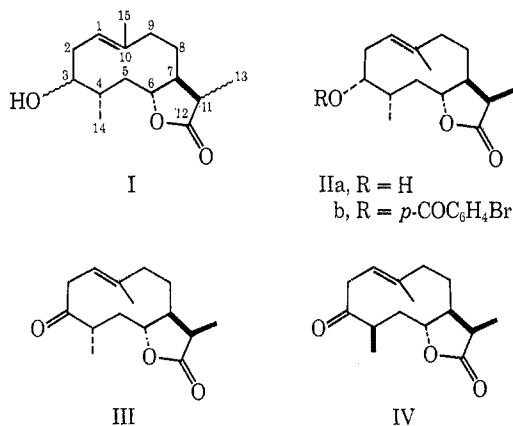
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A crystal structure analysis of the title compound has verified the partial structures previously forwarded for hydroxypelenolide and ketopelenolide a and shows the complete structures to be IIa and III, respectively. Ketopelenolide b is presumably IV. The trans double bond in the ten-membered ring in the crystal is twisted 20°, presumably to relieve nonbonded steric interactions across the ring.

Partial formula I has been proposed for hydroxypelenolide, one of three chemically interrelated sesquiterpene lactones isolated from *Artemisia absinthium* L.<sup>1</sup> To test this proposed formula and to establish the remaining stereochemical features of these substances, the title compound was prepared and subjected to an X-ray study.<sup>2</sup>



## Experimental Section

Crystals suitable for X-ray analysis were kindly prepared by Drs. M. Suchý and V. Herout. After 12 hr, a mixture of hydroxypelenolide (60 mg), *p*-bromobenzoyl chloride (1 ml), and pyridine (2 ml) was poured onto ice water. Recrystallation from methanol gave needles, mp 123–124°. *Anal.* Calcd for C<sub>22</sub>H<sub>27</sub>O<sub>4</sub>Br: C, 60.82; H, 6.23. Found: C, 60.58; H, 6.77. The preliminary X-ray data shown in Table I were obtained from

TABLE I

<i>a</i> , Å	9.72
<i>b</i> , Å	9.82
<i>c</i> , Å	11.05
$\beta$	98.8°
Space group	P2 <sub>1</sub>
Molecules per unit cell	2
Measured <i>d</i> , g/ml	1.33
Calcd <i>d</i> , g/ml	1.33
Observed reflections	837

oscillation and Weissenberg photographs around *b*, the needle axis. The intensities were measured around the *b* axis of a 0.1 × 0.1 × 0.3 mm crystal with a Supper automatic diffractometer using Ni-filtered Cu radiation. A 3° scan at 2°/min and 45 sec background counts were used. Reflections were accepted if the

(1) M. Suchý, Z. Samek, V. Herout, R. B. Bates, G. Snatzke, and F. Šorm, *Collect. Czech. Chem. Commun.*, **32**, 3917 (1967).

(2) Previous X-ray studies of derivatives of sesquiterpenoids with ten-membered rings: Elephantol *p*-bromobenzoate [S. M. Kupchan, Y. Aynehchi, J. M. Cassidy, A. T. McPhail, G. A. Sim, H. K. Schnoes, and A. L. Burlingame, *J. Amer. Chem. Soc.*, **88**, 3675 (1966)], and germaacatriene silver nitrate complex [F. H. Allen and D. Rogers, *Chem. Commun.*, 588 (1967)].

intensity was at least twice the square root of the sum of the scan and background counts.<sup>3</sup> No absorption corrections were made.

The bromine atom was readily located on a Patterson map, and a Fourier map was calculated. After several trials, the aromatic ring and attached COO group were properly placed, and the next Fourier map revealed the remaining nonhydrogen atoms. Anisotropic refinement lowered *R* to 8.5,<sup>4</sup> and, in spite of the small number of reflections, most of the hydrogens could be located on a difference map, and all except those on carbons 11, 13, 15, and 19 were successfully refined to give a final *R* of 7.8. Hydrogens were given the same temperature factors as the carbons to which they were attached, and hydrogen temperature factors were not refined. Bond lengths and angles calculated using ORFFE<sup>5</sup> are given on an ORTEP<sup>6</sup> plot in Figure 1.

## Discussion

This X-ray study verifies the partial structure I forwarded<sup>1</sup> for hydroxypelenolide. In addition, it shows the configurations at C-3, C-11, and of the double bond to be as shown in IIa. Ketopelenolide a, obtained by mild oxidation of hydroxypelenolide, can now be assigned structure III, and ketopelenolide b, obtained from III by mild base treatment, is presumably IV. No attempt was made to verify the *absolute* configurations crystallographically.

During attempts to refine the hydrogens, it was noted that the hydrogen on C-11 kept moving to a position 1.5 Å from C-11, and it was suspected that a small amount of the C-11 epimer of the major structure might be present as an impurity. Accordingly, C-13 and the suspected carbon were assigned normal temperature factors and their multipliers were refined. The multiplier for C-13 dropped to 0.91 and that for the new carbon settled at 0.08. This is in accord with the view that about 8% of the epimer is present, as is the finding of the poorest bond length (C-11–C-13) in this part of the molecule.

The ten-membered-ring conformation approximates a chair-boat with C-3 at the boat apex and C-8 at the chair apex. The ring is considerably more open than a Dreiding model would indicate, presumably due to cross-ring nonbonded steric interactions. The most

(3) Listings of structure factors, coordinates, and anisotropic temperature factors will appear following these pages in the microfilm edition of this volume of the journal. Single copies may be obtained from the Reprint Department, American Chemical Society Publications, 1155 16th St. N.W., Washington D. C. 20036. Remit \$3.00 for photocopy or \$2.00 for microfiche.

(4) Refinements were by full matrix least squares with the ORFLS program of W. R. Busing, K. O. Martin, and H. A. Levy, ORNL-TM-305, Oak Ridge National Laboratory, 1962. Unit weights were used. Form factors were obtained by graphical interpolation of those in the International Tables for X-ray Crystallography, Vol. III, Table 3.3.1A, except for hydrogen, for which the form factors of R. F. Stewart, E. R. Davidson, and W. T. Simpson, *J. Chem. Phys.*, **42**, 3175 (1965), were used.

(5) W. R. Busing, K. O. Martin, and H. A. Levy, ORNL-TM-306, Oak Ridge National Laboratory, 1964.

(6) C. K. Johnson, ORNL-3794.

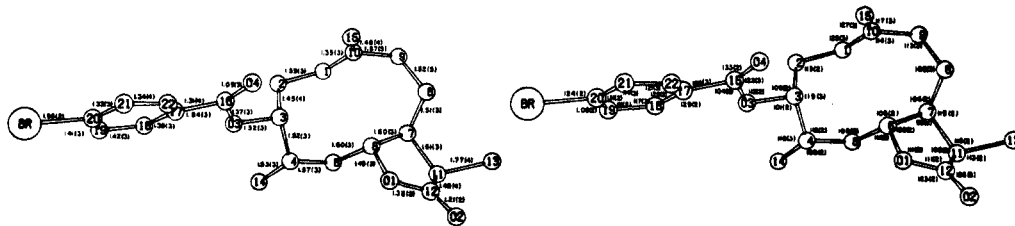


Figure 1.—Left and right eye views of a hydroxypelenolide *p*-bromobenzoate molecule. Bond distances and their standard deviations in angstroms are given on the left eye view, and bond angles on the right eye view.

striking feature of this opening is the angle between the planes formed by C-2-C-1-C-10 and C-1-C-10-C-9, which would be very close to 0° in a simple alkene but is in this case 20°.

**Registry No.**—IIa, 17909-94-3; IIb, 25975-82-0; III, 17909-92-1.

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## Notes

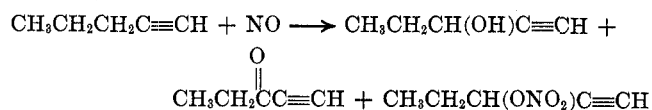
### Reaction of Nitric Oxide with 1-Pentyne

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In contrast to reactions involving the addition of tetrafluorohydrazine to olefins in the presence of nitric oxide which gave predominately difluoramine-*N'*-fluorodiimide *N*-oxides,<sup>1</sup> we have found that with acetylenic compounds the reaction takes an alternate course to give in low-yield products devoid of carbon-nitrogen bonding. It was further established that tetrafluorohydrazine does not enter into the transformation, nor was it necessary for the interaction of nitric oxide with 1-pentyne. In the reaction with 1-pentyne, the products obtained were 1-pentyn-3-ol, 1-pentyn-3-one, and 1-pentyn-3-nitrate.



These reactions were conducted in an evacuated system at ambient temperature by first introducing 1-pentyne with or without solvent ( $\text{HCCl}_3$ ) into a reaction flask which was attached to a glass vacuum system and deaerated by alternate freeze-thaw cycles. The system was then charged with nitric oxide to 500–600 mm of pressure, and the mixture was warmed to reaction temperature for periods of 20–24 hr. Visibly, there was little indication of any reaction except for a

slight decrease in pressure. In all instances, 15–55% of the nitric oxide reacted with the formation of nitrogen, and 1-pentyne was converted to products in low conversions followed by termination of the reaction. This behavior was common to both lighted and covered reaction flask.

Gas chromatography was employed to analyze the product mixtures which showed the presence of three products separated in sufficient quantities on a preparative column for proton nmr spectral analysis. 1-Pentyn-3-ol displayed a triplet ( $J = 7$  cps) centered at  $\tau$  9.01 ( $\text{CH}_3$ ), a quintet ( $J = 7$  cps) at  $\tau$  8.20 ( $\text{CH}_2$ ), a doublet ( $J = 2$  cps) at  $\tau$  7.63 ( $\text{HC}\equiv$ ), a triplet ( $J = 7$  cps) of doublets at  $\tau$  5.74 ( $\text{HC}-\text{O}$ ), and a singlet at  $\tau$  6.46 ( $\text{OH}$ ). A triplet ( $J = 7$  cps) at  $\tau$  8.88 ( $\text{CH}_3$ ), a quadruplet ( $J = 7$  cps) at  $\tau$  7.43 ( $\text{CH}_2$ ), and a singlet at  $\tau$  6.80 ( $\text{HC}\equiv$ ) were exhibited in the spectrum of 1-pentyn-3-one. The nitrate ester of 1-pentyn-3-ol show absorption as a triplet ( $J = 7$  cps) at  $\tau$  8.90 ( $\text{CH}_3$ ), a quintet ( $J = 7$  cps) at  $\tau$  8.11 ( $\text{CH}_2$ ), a doublet ( $J = 2$  cps) at  $\tau$  7.48 ( $\text{HC}\equiv$ ), and a triplet ( $J = 7$  cps) of doublets ( $J = 2$  cps) at  $\tau$  4.68 ( $\text{HC}-\text{O}$ ). All peak areas were in the appropriate ratio, and the spectra and glc retention times were identical with those of authentic samples of the three compounds.

Treatment of 1-pentyn-3-ol with nitric oxide under the same conditions gave the ketone and nitrate ester in low yields, and again, the reaction stopped at low conversions. Similarly, when 1-hexyne was treated with nitric oxide the corresponding alcohol, ketone and nitrate ester were formed with low conversion of 1-hexyne to products.

The preliminary results point to a free-radical process; however, nitric oxide while known<sup>2</sup> to be very efficient at trapping hydrocarbon radicals is not par-

(1) S. F. Reed, Jr., *J. Org. Chem.* **32**, 3869 (1967).

(2) J. F. Brown, Jr., *J. Amer. Chem. Soc.*, **79**, 2480 (1957).