THE STEREOCHEMISTRY AND ABSOLUTE CONFIGURATION
OF ABIENOL

By R. M. Carman

Abienol, the diterpenoid alcohol present in Abies oleoresin and in particular obtainable from the oleoresin of Abies balsamea (Canada balsam), has been assigned the structure (I) (without stereochemical implications).

During a recent survey of optical rotation and structure in the bicyclic diterpenoid series, it was observed that abienol had an unexpectedly high rotation. If simple molecular rotation differences are meaningful, then abienol (I) should have a rotation approximately equal to that of sclareol (II) ([M]D = -15) plus bifornene (IV) ([M]D = 33) minus manool (V) ([M]D = 96); i.e. a molecular rotation of -78 units. Abienol in fact has [M]D = 70 which led to the suggestion that abienol...
might have the structure antipodal to (I). The evidence for the structure supplied by earlier workers,\(^a\,^5\) which was based upon the reduction of abienol to (III) \([\alpha]_D +1.5^\circ\); reported\(^7\) for authentic (III), \([\alpha]_D -1^\circ\), did not allow an absolute assignment of structure to be made. Consequently abienol has now been degraded to a compound of known absolute configuration and of large specific rotation.

Direct oxidation of abienol with osmium tetroxide and periodate, or with permanganate-periodate, gave a crystalline neutral compound, m.p. 122–123\(^\circ\). This compound, \(\mathrm{C}_{19}\mathrm{H}_{32}\mathrm{O}_2\), showed characteristic \(\gamma\)-lactone absorption in the infrared, and had an infrared spectrum superimposable upon that recorded\(^8\) for norambreinolide. A positive optical rotation indicated that the oxidation product was \((+)-\)norambreinolide which has the known\(^6\,^9\) absolute configuration (VI). This evidence provides proof of the absolute configuration of abienol (I), and also for the relative stereochemistry at C8.

![Diagram](image)

**Table 1**

<table>
<thead>
<tr>
<th>Compound</th>
<th>(\mathbf{H}_A)</th>
<th>(\mathbf{H}_B)</th>
<th>(\mathbf{H}_X)</th>
<th>(\mathbf{H}_Y)</th>
<th>(J_{\mathbf{AB}})</th>
<th>(\lambda_{\text{max}})</th>
<th>(\epsilon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abienol (I, VII)</td>
<td>4.93</td>
<td>5.00</td>
<td>3.15</td>
<td>4.55</td>
<td>(\approx 2)</td>
<td>238</td>
<td>19800</td>
</tr>
<tr>
<td>(\text{cis}-\alpha)-Ocimenone(^{11}) (VII)</td>
<td>4.96</td>
<td>5.03</td>
<td>3.35</td>
<td>4.77</td>
<td>1.8</td>
<td>234.5</td>
<td>21600</td>
</tr>
<tr>
<td>(\text{cis}-\beta)-Ocimenone(^{11}) (VII)</td>
<td>4.89</td>
<td>4.87</td>
<td>3.27</td>
<td>4.72</td>
<td>1.8</td>
<td>237.5</td>
<td>21000</td>
</tr>
<tr>
<td>(\text{cis}-\text{Methyl} \text{ commutate}(^{12}) (VII)</td>
<td>4.93</td>
<td>5.00</td>
<td>3.18</td>
<td>4.80</td>
<td></td>
<td>235</td>
<td></td>
</tr>
<tr>
<td>(\text{trans-Methyl commutate}(^{12}) (VII)</td>
<td>4.98</td>
<td>5.15</td>
<td>3.72</td>
<td>4.60</td>
<td>1</td>
<td>232</td>
<td>27600</td>
</tr>
<tr>
<td>(\text{trans}-\alpha)-Ocimenone(^{11}) (VIII)</td>
<td>4.98</td>
<td>5.12</td>
<td>3.69</td>
<td>4.58</td>
<td>1.2</td>
<td>231</td>
<td>27300</td>
</tr>
<tr>
<td>(\text{trans}-\beta)-Ocimenone(^{11}) (VIII)</td>
<td>5.00</td>
<td>5.13</td>
<td>3.70</td>
<td>4.61</td>
<td>1.2</td>
<td>232</td>
<td>27600</td>
</tr>
</tbody>
</table>

The proton magnetic spectrum of abienol confirms the gross structure (I) and provides evidence concerning the \(\text{cis}\) nature of the \(\Delta^{12}\) double bond. The C12 proton occurs as a broad triplet at 4.55 \(\tau\) \((J \approx 7 \text{ c/s})\) and the C15 and C16 protons occur as a seven-line ABX system (four X lines, three broad AB lines). The results of the analysis of this system are listed in Table 1. Results from similar systems

\(^{12}\) Thomas, B. R., private communication.
which have been tabulated in the literature,\textsuperscript{10-12} and which have already been used to determine cis/trans isomerism in similar compounds (types VII and VIII), are also listed. The values for abienol, especially the value for the H\textsubscript{9} proton which shows the greatest variation between cis and trans isomers, indicate that abienol almost certainly has the cis configuration (VII) rather than the trans structure (VIII). This view is supported by the peak position and intensity of the ultraviolet absorption of abienol\textsuperscript{6} (see Table 1).

With the absolute configuration and stereochemistry of abienol established as (I), the optical rotation of abienol (or alternatively of biformene and trans-communic acid)\textsuperscript{6} remains anomalous. However, the diterpenoids (II-V) with which abienol was compared do not have a cis-\Delta\textsuperscript{12} double bond, nor do they have an 8-\alpha-hydroxy-\Delta\textsuperscript{12}-labdene system which could possibly form a hydrogen bond, and it may therefore be either of these features which causes the variation in optical rotation. It is hoped to check these views in the near future by synthesis of model compounds.

**Experimental**

**Abienol (I)**

Abienol was isolated from commercial Canada balsam (F. W. Berk & Co. Ltd, London) essentially as described by Gray and Mills,\textsuperscript{8} m.p. 40\degree, \([\alpha]_D +22\degree \text{ (c, 0.9 in CHCl}_3\text{).} \] The p.m.r. spectrum (CCl\textsubscript{4}) showed 3.15 (C 15; quartet), 4.55 (C 12; broadened triplet), 4.93, 5.00 (C 16; C 16'; three broadened lines), 7.73 (C 11; complex), 8.21 (C 17 methyl, fine doublet; \( J \) 1 c/s), 8.88 (C 14 methyl), 9.12, 9.17, 9.21 (C 18, C 19, C 20 methyls) \( \tau \). \([J_{11,18} 7 \text{ c/s, } J_{15,16} 18 \text{ c/s, } J_{15,14} 10 \text{ c/s, } J_{16,14} 2 \text{ c/s.})\]

\((+)-\text{Norambreinolide (VI)}\)

Abienol (2 g) in aqueous dioxan was treated with osmium tetroxide (0.1 g) and excess periodio acid. After 70 hr the flask containing a brown oil was worked up in the normal manner to give a trace of acidic material together with a neutral fraction. The neutral material, when chromatographed over alumina, gave, on elution with light petroleum, (+)-norambreinolide, m.p. 122-123\degree (after numerous recrystallizations from light petroleum and from methanol/water); \([\alpha]_D +42\degree \text{ (c, 0.25 in CHCl}_3\text{).} \] (Found: C, 76.5; H, 10.3. Calc. for C\textsubscript{39}H\textsubscript{44}O\textsubscript{4}: C, 76.75; H, 10.5\%). The infrared spectrum was completely superimposable upon that recorded in the literature\textsuperscript{8} for authentic (+)-norambreinolide.

An attempt to purify the lactone by sublimation (75\%/0.1 mm) resulted in decomposition to give crystals, m.p. 90-95\degree.

Abienol, on oxidation with permanganate/periodate in aqueous t-butanol under weakly alkaline conditions using the method of Von Rudloff,\textsuperscript{13} but requiring the occasional addition of further quantities of permanganate, gave (+)-norambreinolide, m.p. 122\degree, \([\alpha]_D +39\degree \text{.}\]

**Acknowledgments**

We thank Mr A. Fletcher for obtaining the supply of Canada balsam, and are indebted to Dr B. R. Thomas for the data concerning cis-communic acid.

\textsuperscript{8} Literature values\textsuperscript{13,14} for (+)-norambreinolide, m.p. 122-126\degree, \([\alpha]_D +46\degree \text{.} \] The structure for this compound is incorrectly represented at C 8 in Simonsen, J., and Ross, W. C. J., "The Terpenes" Vol. V, pp. 602-3 (Cambridge University Press 1957).

