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NOMENCLATURE OF PRENOLS
(Recommendations 1986)

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The prenols are a group of alcohols containing one or more isoprene units, and are, with their esters, the biological precursors of the isoprenoids, a variety of compounds including terpenes and steroids that contain much of the carbon skeleton intact. The new recommendations do not replace any existing document, but set out to systematize existing practice, and to supplement it by paying full attention to the important stereochemistry of the prenols. The general terms are discussed and recommendations for indicating stereochemistry are made. Short-chain prenols that have established trivial names are listed, and the relationship of the prenols to the simplest juvenile hormones is indicated.

INTRODUCTION

Present practice in the nomenclature of prenols takes little account of the important stereochemistry of these compounds. We therefore believe that a review of existing practice, with recommendations for specifying stereochemistry, should be helpful. Some of the recommendations have been used in Enzyme Nomenclature [1].

GENERAL TERMS

Pr-1 Prenol. The term prenol, already widely used (e.g. refs. 2,3,5,6), is recommended to describe the structure shown in formula I. It originated as a contracted name for isoprenoid alcohol (i.e. suffix -ol) [2].

\[ \text{CH}_3 \]

\[ H-\{\text{CH}_2-\text{C}=(\text{CH}_2)_n\}-\text{OH} \]

I

The carbon atoms along the main chain are numbered from C-1, the atom that carries the hydroxyl group (C-15.11 of ref. 8). The methyl group carried by atom C-3 contains atom C-3', that carried by atom C-7 contains atom C-7', etc.

Note

This use of superscript numbers is based on section TP-2.1 of the recommendations for the nomenclature of tetrapyrroles [9]. In the printing of these recommendations in the European Journal of Biochemistry the relevant paragraph was accidentally transposed to the caption of Table 2.

The repeating C5H10 unit (inside the brackets of structure I) is termed an isoprene unit or an isoprene residue. Prenols and their esters are precursors of a variety of compounds, including terpenes and steroids, that have much of the carbon skeleton intact. Such compounds are known as isoprenoids.
Nomenclature of prenols

Pr-2. Polyprenol. Polyprenols represent a subgroup of prenols. The term polyprenol, already widely used (e.g. ref. 2), is recommended for compounds of structure I in which $n$ is greater than 4.

Pr-3. Esters and their derivatives. The terms prenyl diphosphate (or diphosphoprenol) and polyprenyl diphosphate (or diphosphopolyprenol), already widely used, are recommended for the esters of I with diphosphoric acid, and for the salts and anions of such esters. They are in accordance with recommendations for naming phosphorus-containing compounds [7].

Note

The term prenyl diphosphate is preferred to diphosphoprenol, because diphosphate has precedence over hydroxyl for being cited as suffix (C-10.3 of ref. 8).

Pr-4. Number of residues. The number of isoprene residues, i.e. the value of $n$ in Formula I, in each molecule of a polyprenol or derivative should be indicated by a multiplicative prefix [10] instead of the general prefix poly- suggested in recommendation Pr-2, e.g. hexaprenol, heptaprenyl diphosphate.

STEREOCHEMISTRY

Pr-5. Double bonds. The double bond in a residue is called cis or trans according to whether the main chain of the compound is cis or trans across that double bond. A residue containing a cis double bond may be called a cis residue, and one containing a trans double bond may be called a trans residue.

Note

The designations cis and trans refer to the configuration of the main chain across a double bond. Thus, unlike $Z$ and $E$ [11], they are independent of any substituents that may be present. This recommendation does not preclude the use of $Z$ and $E$.

Pr-6. Order of stereochemical prefixes. The residue furthest from the hydroxyl group is referred to as the $\omega$-residue, and stereochemical designations are given in order from the residue next to the $\omega$-residue, ending with the residue that carries the hydroxyl group, e.g. ditrans,polycis-undecaprenol (II):

1. The distinction between cis and trans forms does not exist for the $\omega$-residue unless one of the two methyl groups is substituted. Therefore, stereochemical designators are given starting from the residue next to the $\omega$-residue.

2. It is not advisable to omit stereochemical designations, as this can give ambiguity. Thus the name heptaprenyl diphosphate was applied [12] to the all-trans compound from a bacterium, but could be confused with ditrans,polycis-heptaprenyl diphosphate, which is found in silver birch and other plants [13]. The name undecaprenyl diphosphate was likewise applied [14] to the bacterial ditrans,polycis compound, which could cause confusion with the tritrans,polycis compound found in the leaves of higher plants [15].

Fig. 1. The chain-lengthening step in prenol biosynthesis
3. Although large numbers of stereoisomers could arise if each newly added residue (Fig. 1) could be either cis or trans, the commonest prenols are confined to four main groups (Fig. 2), as follows: (i) all-trans-prenols, (ii) ditrans,poly cis- prenols, (iii) tritrans,poly cis- prenols, and (iv) all-cis-prenols. The symbols W, T and C that appear in Fig. 2, together with a fourth symbol S, provide a convenient set for compactly representing polyisoprenol structures.

In group (i), the term 'all-trans' means that all the residues except the w-residue have the trans configuration. In groups (ii) and (iii) the trans residues are grouped next to the w-residue. Group (iv) is less well characterized, but probably exists as precursors of natural rubber.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>w-Residue</td>
</tr>
<tr>
<td>T</td>
<td>trans-Residue</td>
</tr>
<tr>
<td>C</td>
<td>cis-residue</td>
</tr>
<tr>
<td>S</td>
<td>saturated (dihydro)</td>
</tr>
</tbody>
</table>

Each arrow shows a transformation of the type given in Fig. 1. Upward sloping arrows represent trans additions of a unit from isopentenyl diphosphate (section Pr-9), and downward sloping arrows represent cis additions. An arabic numeral adjacent to an arrow indicates that an enzyme catalysing the reaction has been characterized and listed under that number in group EC 2.5.1 of Enzyme Nomenclature [1], e.g. EC 2.5.1.11 catalyses the conversion of geranyl-POP into trans,trans-farnesyl-POP. The groups given in the right-hand column refer to the main classes of polyisoprenols as listed in section Pr-6, note 3. Where locants are included the prefixes appear in locant order (section Pr-8), not in left-to-right order (section Pr-6). In the symbolic representations, W represents an w-residue, T a trans residue, and C a cis residue.
4. The recommendation to cite stereochemical prefixes in the reverse order from their
locants is contrary to normal recommendations. We make it because (1) it is already
widely used, (2) it corresponds to the left-to-right order in most drawings of
formulas and symbolic representations of prenols and their diphosphates, and (3) it
names first the double bonds formed first in biosynthesis.

Example
all-trans-Nonaprenol is the plant product solanesol, which contains nine isoprene
units, eight of which are trans, the ninth being the ω-residue.

Pr-7. Multiplicative prefixes. The prefix poly- may be replaced by an appropriate
multiplicative prefix; e.g. the bacterial product bactoprenol can be called ditrans,octa-
cis-undecaprenol rather than ditrans,poly cis-undecaprenol.

Note
If this recommendation is followed it is not advisable to omit the multiplicative
prefix indicating the total number of residues, even though it contains redundant
information. In ditrans,octa cis-undecaprenol, for example, a prenol with one ω, two
trans and eight cis residues must have eleven residues in all.

SPECIFIC COMPOUNDS

Pr-8. Trivial names. Several short-chain prenols are known by trivial names. For example, the
diphosphates with one to five residues are named as follows:

<table>
<thead>
<tr>
<th>Number of residues</th>
<th>Stereochemistry</th>
<th>Trivial name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(none)</td>
<td>dimethylallyl diphosphate</td>
</tr>
<tr>
<td>2</td>
<td>trans</td>
<td>geranyl diphosphate</td>
</tr>
<tr>
<td></td>
<td>cis</td>
<td>neryl diphosphate</td>
</tr>
<tr>
<td>3</td>
<td>2-trans,6-trans</td>
<td>farnesyl diphosphate</td>
</tr>
<tr>
<td></td>
<td>2-cis,6-trans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-trans,6-cis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-cis,6-cis</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2-trans,6-trans,10-trans</td>
<td>geranylgeranyl diphosphate</td>
</tr>
<tr>
<td></td>
<td>2-cis,6-trans,10-trans</td>
<td>geranylneryl diphosphate</td>
</tr>
<tr>
<td>5</td>
<td>2-trans,6-trans,10-trans,14-trans</td>
<td>geranylfarnesyl diphosphate</td>
</tr>
<tr>
<td></td>
<td>2-cis,6-trans,10-trans,14-trans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-cis,6-cis,10-trans,14-trans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-cis,6-cis,10-trans,14-trans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-cis,6-cis,10-trans,14-trans</td>
<td></td>
</tr>
</tbody>
</table>

Dimethylallyl diphosphate (strictly 3,3-dimethylallyl diphosphate), geranyl diphosphate and
neryl diphosphate are entirely specified by name, and need no further stereochemical
designation. Dimethylallyl is the trivial name for 3-methylbut-2-enyl. The name dimethylallyl
does not conform to ref. 8, and is ambiguous if used outside biochemical contexts.

The name farnesyl diphosphate covers four C_{15} stereoisomers. It is confusing that they have
been designated trans,trans, cis,trans, trans,cis and cis,cis, with the first designator
applying to C-2 and the second to C-6 [16], i.e. the reverse order from that used for poly-
prenols (recommendation Pr-6). We therefore recommend that locants should be used to minimize
confusion, e.g. 2-cis,6-trans-farnesyl diphosphate; this becomes trans,cis when lengthened to
form the ω-terminus of a poly prenol.

Two C_{20} prenyl groups have been named geranylgeranyl and geranylneryl; in them the second
isoprene residue from the oxygen atom is always trans, i.e. the group is 6-trans. The use of
these terms is so widespread and well established that it would probably be damaging to
recommend changes. Other compounds should be named according to sections Pr-4 to Pr-7, e.g.
dicis,trans-tetraprenyl diphosphate for the compound with 2-trans-6,10-dicis stereochemistry.

Note
We see no harm in using the poly prenol system (sections Pr-4 to Pr-7) for C_{n}
compounds (i.e. naming them as tetraprenols). This usage eliminates the inconsist-
ency of reversing the order of stereochemical designators for compounds of fewer
than five residues.
Pr-9. Isopentenyl diphosphate. An important isomer of dimethylallyl diphosphate is isopentenyl diphosphate (structure III), the diphosphate of 3-methylbut-3-en-1-ol (isopentenyl alcohol). It is the universal building block of isoprenoids; a prenyl diphosphate reacts with it to lose diphosphate and grow longer by one residue (Figs. 1 and 2). Its name should be retained.

\[ \text{CH}_3 \]
\[ \text{CH}_2 = \text{C} = \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{O} - \text{P} - \text{O} - \text{P} \]

III

Notes
1. The CH= group of isopentenyl alcohol contains C-4 [see recommendation C-13.11(b) of ref. 8]. This is convenient, as C-4 of isopentenyl diphosphate is the precursor of C-4 of a lengthened prenol (Fig. 1).
2. The name isopentenyl is recommended only for biochemical use; it does not conform to ref. 8 and is ambiguous outside biochemical and prenol contexts. Isopentenyl is the trivial name for 3-methylbut-3-enyl.

Pr-10. Relationship between polyrenols and isoprenoids. The derived isoprenoids are named as follows:

<table>
<thead>
<tr>
<th>Number of residues</th>
<th>Prenol precursor (as diphosphate, etc.)</th>
<th>Terpenoid class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>dimethylallyl alcohol</td>
<td>hemiterpenoid</td>
</tr>
<tr>
<td>2</td>
<td>geraniol or nerol</td>
<td>monoterpenoid</td>
</tr>
<tr>
<td>3</td>
<td>farnesol</td>
<td>sesquiterpenoid</td>
</tr>
<tr>
<td>4</td>
<td>geranylgeraniol</td>
<td>diterpenoid</td>
</tr>
<tr>
<td>5</td>
<td>geranyl farnesol</td>
<td>sesterterpenoid</td>
</tr>
<tr>
<td>6</td>
<td>farnesol*</td>
<td>triterpenoid*</td>
</tr>
<tr>
<td>8</td>
<td>geranylgeraniol†</td>
<td>tetraterpenoid or carotenoid†</td>
</tr>
<tr>
<td>many</td>
<td></td>
<td>rubber (all-cis) or gutta percha (all-trans)</td>
</tr>
</tbody>
</table>

*Triterpenoids are formed from squalene, which is derived from two farnesyl diphosphate precursor molecules.

†Carotenoids are formed from phytoene, which is derived from two geranylgeranyl diphosphate precursor molecules.

Pr-11. Juvenile hormones. Farnesol is the prenol that corresponds to the carbon skeleton of the simplest juvenile hormone. Other members of this group of compounds have an ethyl instead of a methyl group at C-3 and/or C-7 and/or C-11. These may be specified as methyl-substituted farnesol derivatives where the stereospecificity of the &-isoprene unit (where relevant) is indicated by which methyl group is substituted.

Examples

\[ \text{CH}_3 - \text{CH}_2 \]
\[ \text{CH}_3 \]
\[ \text{CH}_2 = \text{C} = \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{C} = \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \]
\[ \text{OH} \]

ditran-11'-methylfarnesol

\[ \text{CH}_3 \]
\[ \text{CH}_3 - \text{CH}_2 \]
\[ \text{CH}_3 \]
\[ \text{CH}_2 = \text{C} = \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{C} = \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \]
\[ \text{OH} \]

ditran-7',12-dimethylfarnesol

Pr-12. Dolichols. Dolichols are a group of prenol derivatives. The term, already widely used (e.g. ref. 2), is recommended for compounds of structure I in which \( n \) is greater than 4 and in which the residue that carries the hydroxyl group is saturated, i.e. 2,3-dihydropolyprenols. As dolichols are derivatives of prenols the collective term prenol should not be used without qualification to include dolichols.
REFERENCES


11. International Union of Pure and Applied Chemistry (1976) Stereochemistry, Pure Appl. Chem. 45, 11-30 (1976); also pp. 1-5 in ref. 4 and Section E of ref. 8.


