Unit-I
Nomenclature of Heterocyclic compounds

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Three systems for naming heterocyclic compounds:

1) The common nomenclature: no structural information but it still widely used.

2) The replacement method

3) The Hantzsch-Widman (IUPAC or Systematic) method which is designed so that one may deduce from it the structure of the compound.
I- Common Nomenclature

每位化合物都给出了相应的普通名称。这通常起源于化合物的出现、其首次制备或其特殊性质。

1. 如果存在同一种类型的多个杂原子，则编号从饱和的杂原子开始，例如：咪唑。

2. 如果存在不同类型的多个杂原子，则环从优先级较高的杂原子（O>S>N）开始编号，并继续朝向给其他杂原子尽可能低的编号方向。

![Diagram of a heterocyclic compound]

- 第一个 heteroatom 的编号从 1 开始，第二个 heteroatom 的编号从 2 开始，依此类推。
- 环状化合物的编号从环上的饱和 heteroatom 开始，继续按顺时针或逆时针方向编号。
- 当存在多个杂原子时，编号从优先级最高的杂原子开始，并按顺时针或逆时针方向依次编号。
- 当存在多个不同类型的杂原子时，编号从优先级最高的杂原子开始，并按顺时针或逆时针方向依次编号。

例：

- 五个杂原子的环状化合物，编号从 1 开始，依次为 1, 2, 3, 4, 5。
- 六个杂原子的环状化合物，编号从 1 开始，依次为 1, 2, 3, 4, 5, 6。
- 七个杂原子的环状化合物，编号从 1 开始，依次为 1, 2, 3, 4, 5, 6, 7。

- 五个杂原子的环状化合物，编号从 1 开始，依次为 1, 2, 3, 4, 5。
- 六个杂原子的环状化合物，编号从 1 开始，依次为 1, 2, 3, 4, 5, 6。
- 七个杂原子的环状化合物，编号从 1 开始，依次为 1, 2, 3, 4, 5, 6, 7。

- 五个杂原子的环状化合物，编号从 1 开始，依次为 1, 2, 3, 4, 5。
- 六个杂原子的环状化合物，编号从 1 开始，依次为 1, 2, 3, 4, 5, 6。
- 七个杂原子的环状化合物，编号从 1 开始，依次为 1, 2, 3, 4, 5, 6, 7。
I-Common Nomenclature

- If substituents present, their position should be identified by the number of the atoms bearing them and then they should be listed in alphabetical order.

- The words dihydro, or trihydro, or tetrahydro are used if two or three or four atoms are saturated. These words are preceded by numbers indicate the position of saturated atoms as low as possible and followed by the corresponding fully unsaturated trivial name.
1) 5-membered heterocycles with one or two heteroatoms

- Furan
- Thiophene
- Pyrrole
- Imidazole
- Pyrazole
- Isoxazole
- Oxazole
- Thiazole

These are tautomers. Both are not aromatic.

2) 6-membered heterocycles with one or two heteroatoms

Common azines-six-membered aromatic nitrogen heterocycles

- Pyridine
- Pyridazine
- Pyrimidine
- Pyrazine

DNA/RNA bases

5
3) Fused heterocycles

**common ring-fused azoles**

- indole
  - (found in the amino acid tryptophan)
- isoindole
- indazole
- purine
  - (DNA/RNA base)
- indolizidine

**common ring-fused azines**

- quinoline
- isoquinoline
- quinazoline
- pteridine
  - (found in the B vitamin riboflavin)
- quinolizidine

Guanine
4) Saturated heterocycles

- pyrrolidine
- piperidine
- piperazine
- morpholine
II- Replacement nomenclature

- Heterocycle’s name is composed of the corresponding carbocycle’s name and an elemental prefix for the heteroatom introduced (if more than one heteroatom is present they should be listed according to the priority order shown in (table 1).

Table 1

<table>
<thead>
<tr>
<th>Atom</th>
<th>Prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>oxa</td>
</tr>
<tr>
<td>Se</td>
<td>selena</td>
</tr>
<tr>
<td>S</td>
<td>thia</td>
</tr>
<tr>
<td>N</td>
<td>aza</td>
</tr>
<tr>
<td>P</td>
<td>phosha</td>
</tr>
</tbody>
</table>
## II- Replacement nomenclature

<table>
<thead>
<tr>
<th>Structure</th>
<th>Name</th>
<th>Nomenclature</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Benzene" /></td>
<td>Benzene</td>
<td>1,4-Diazabenzenne</td>
</tr>
<tr>
<td><img src="image" alt="Cyclopentadiene" /></td>
<td>Cyclopentadiene</td>
<td>Oxacyclopenta-2,4-diene</td>
</tr>
<tr>
<td><img src="image" alt="Cyclopentadiene" /></td>
<td>Cyclopentadiene</td>
<td>1-Oxa-3-azacyclopenta-2,4-diene</td>
</tr>
<tr>
<td><img src="image" alt="Cyclopropane" /></td>
<td>Cyclopropane</td>
<td>Oxacyclopropane</td>
</tr>
<tr>
<td><img src="image" alt="Cyclopropene" /></td>
<td>Cyclopropene</td>
<td>Oxazacyclopropene</td>
</tr>
<tr>
<td><img src="image" alt="Cyclopentadiene" /></td>
<td>Cyclopentadiene</td>
<td>1-Thia-2-azacyclopenta-2,4-diene</td>
</tr>
<tr>
<td><img src="image" alt="Cyclohexane" /></td>
<td>Cyclohexane</td>
<td>1-Oxa-4-azacyclohexane</td>
</tr>
<tr>
<td><img src="image" alt="Naphthalene" /></td>
<td>Naphthalene</td>
<td>2-Azanaphthalene</td>
</tr>
</tbody>
</table>
III-Hantzsch-Widman nomenclature (IUPAC)

- German chemists Arthur Hantzsch and Oskar Widman, proposed similar systematic naming of heterocyclic compounds in 1887 and 1888 respectively.

- three to ten-membered rings named by combining the appropriate prefix (or prefixes) that denotes the type and position of the heteroatom present in the ring with suffix that determines both the ring size and the degree of unsaturation

- In addition, the suffixes distinguish between nitrogen-containing heterocycles and heterocycles that do not contain nitrogen

- IUPAC name = locants+ prefix + suffix
1) Identify the heteroatom present in the ring and choose from (table 1 on slide 8) the corresponding prefix.

2) The position of a single heteroatom control the numbering in a monocyclic compound. The heteroatom is always assigned position 1 and if substituents present are then counted around the ring in a manner so as to take the lowest possible numbers.

For example:
3) A multiplicative prefix (di, tri, ect.) and locants are used when two or more similar heteroatoms contained in the ring (two nitrogen indicated by diaza) and the numbering preferably commenced at a saturated rather than an unsaturated atom, as depicted in the following example: 1,3-diaza.

4) If more than one type of heteroatoms present in the ring the name will include more than one prefix with locants to indicate the relative position of the heteroatoms.

• When combining the prefixes (e.g. oxa and aza) two vowels may end up together, therefore the vowel on the end of the first part should be omitted (oxaza).
The numbering is started from the heteroatom of the highest priority in such a way so as to give the smallest possible numbers to the other heteroatoms in the ring (the substituents are irrelevant). For example the prefix corresponding to the following compound is 4-Methyl-1,3-Thiaza....

5) Choose the appropriate suffix from (table 2) depending on whether or not nitrogen atom is present in the ring, the size of the ring and presence or absence of any double bonds

6) Combine the prefix(s) and suffix together and drop the first vowel if two vowels came together.
Hantzsch-Widman rules

Table 2

Ring size

N-present

Unsat
irine
etaine
oleine
epine
ocine
online
ecine

Sat
iridine
etidine
olidine
ane
ane
ane
ane

N-absent

Unsat
irene
etetane
ol etane
epinane
ocinane
oninane
ecnane

Sat
irane
etane
olane
ane
ane
ane
ane

a: means use the prefix perhydro followed by the fully unsaturated name
Hantzsch-Widman rules

- **Examples**

  ![Hantzsch-Widman rule example](image)

  - This ring contains (N) **Prefix is aza**
  - The ring is 3-membered and fully saturated **suffix is iridine**
  - By combining the prefix and suffix, two vowels ended up together (azairidine), therefore the vowel on the end of the first part should be dropped. This gives the correct name: **Aziridine**
Hantzsch-Widman rules

• This ring contains (O,N) and (o) has higher priority than (N) and by starting numbering the ring at (O) Prefix is 1,2-Oxaaza, but the first vowel must be omitted to give 1,2-Oxaza

• The ring is 4-membered and fully saturated suffix is etidine

• By combining the prefix and suffix, two vowels ended up together (1,2-oaxazaetidine), therefore the vowel on the end of the first part should be dropped. This gives the correct name: 1,2-oxazetidine
This ring contains (O) prefix1 (oxa), and two (N) prefix2 diaza.

Locants, since (O) is higher priority than (N) so it is in position 1 by default and the two (N) are therefore at positions 2 and 5, this gives the combined prefixes as **1,2,5-oxadiaza** (note that the a in oxa is not dropped).

It is 5-membered, fully unsaturated ring with (N) the suffix is **ole**.

By combining the prefixes and the suffix and dropping the appropriate vowels we get the correct name as **1,2,5-Oxadiazole**.
The ring is 6-membered, fully saturated with nitrogen. Prefix *perhydro* followed by the name of fully unsaturated 6-membered ring with nitrogen azine.

Thus the full name is **perhydroazine**.
Partial unsaturation in heterocyclic compounds can be indicated by one of the following methods:

a) The position of nitrogen or carbon atoms which bear extra hydrogen atoms must be indicated by numbers and italic capital H (e.g. 1H, 2H, etc.) followed by the name of maximally unsaturated ring.

![Chemical structures](image-url)
b) The words dihydro, or trihydro, or tetrahydro are used if two or three or four atoms are saturated. These words are preceded by numbers indicate the position of saturated atoms as low as possible and followed by the corresponding fully unsaturated Hantzsch-Widman name.

1,2-Dihydroazine  
1,4-Dihydroazine  
2,3,4,5-Tetrahydroazine  
2,3-Dihydrooxole
Hantzsch-Widman rules for partially unsaturated heterocycles

c) Alternatively, the partially unsaturated 4 and 5 rings (i.e. rings contain one double bond) are given special Hantzsch-Widman suffixes as in table 3 and the double bond is specified as $\Delta^1, \Delta^2, \Delta^3$, etc. Which indicates 1 and 2; 2 and 3; 3 and 4 atoms respectively have a double bond

(i.e. Name : $\Delta^x$ + Prefix + special suffix )
( $x =$ locant of the double bond)
Hantzsch-Widman rules for partially unsaturated heterocycles

- **Examples**

\[
\begin{align*}
\Delta^2 \text{-Azetine} & & \Delta^2 \text{-Oxetene} \\
\Delta^3 \text{-Azoline} & & \Delta^2 \text{-Oxolene} \\
\Delta^4 \text{-1,3-Thiazoline} & & \Delta^2 \text{-1,3-Diazoline}
\end{align*}
\]
**Exercise:**

Explain how can you name the following heterocycles.

- 1,3-Oxathiolane
- 1,3,5 triazine
- Oxirene
- 4 bromo 1,3 thiazole