Beer. It has four core ingredients: water, malted barley, hops and yeast. These ingredients are united to give us one of the most revered and diverse alcoholic beverages of all time. Hundreds of biological and chemical processes need to work together in harmony during its production and the complexity doesn’t end there.

The crystal clear glass used to serve beer in its cold, foamy, and fizzy glory is made possible by advances in science, which not only allows for the production of the pint glass, but the beer as well. Increasingly, hops are becoming the central focus for those who are aiming to create a new and unique flavor in today’s craft brewing scene.

**HOP CHEMISTRY**

**Off Flavors**

<table>
<thead>
<tr>
<th>Flavor</th>
<th>Chemical Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>isoamyl acetate</td>
</tr>
<tr>
<td>Butter</td>
<td>2,3-butanedione</td>
</tr>
<tr>
<td>Eggs</td>
<td>hydrogen sulfide</td>
</tr>
<tr>
<td>Green Apples</td>
<td>acetaldehyde</td>
</tr>
<tr>
<td>Skunk</td>
<td>3-methyl-2-butene-1-thiol</td>
</tr>
<tr>
<td>Cheesy</td>
<td>isovaleric acid</td>
</tr>
</tbody>
</table>

By understanding the chemical structure of beer, we can create so many different flavors—good and bad. Here are some examples of tried “off flavors” and their chemical structures, that are perhaps best to stay away from.

**Alpha-acids**

Important class of compounds found in hops are the so-called alpha-acids. These degrade when heated (via an isomerization) to produce iso-acids, which are intensely bitter. The most important of these are...

![Alpha-acids Diagram](https://www.elsevier.com/solutions/reaxys)

**Bitterness**

Alpha acid “rating” on hops indicates the amount of alpha acid as a percentage of total weight of the hop. Hops with a higher alpha acid content will contribute more bitterness than a lower alpha acid hop when using the same amount of hops. High alpha acid varieties of hops are more efficient for producing highly bitter beers.

**Preservation**

Colored bottles have been shown to limit the problems with “light struck” or “skunky” beer, caused by UV light. This is characterized by the formation of 3-methyl-2-butene-1-thiol (MBT), which is also found in the infamous secretions of skunks.
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- Banana: isoamyl acetate
- Butter: 2,3-butanedione
- Eggs: hydrogen sulfide
- Green Apples: acetaldehyde
- Skunk: 3-methyl-2-butene-1-thiol
- Cheesy: isovaleric acid

An important class of compounds found within hops are the so-called alpha-acids. These degrade when heated (via an isomerization) to produce iso-acids, which are intensely bitter. The most important of these are:

- Alpha-acids: Humulone, Cohumulone, Adhumulone

Hops are not just added to beer to make it taste bitter. It is also highly valued for the characteristic floral and citrus aromas that it imparts.

Aroma

- Citrus: Cascade, Centennial
- Floral: Centennial, Hallertauer, Hersbrucker, Mt Hood, Wilamette
- Fruity: Hallertauer Hersbrucker, Northern Brewer, Willamette
- Spicey: Mt Hood, Chinook, Styrian Goldings, Willamette
- Herbal: Willamette
- Woody: Northern Brewer
- Piney: Chinook

The alpha acid “rating” on hops indicates the amount of alpha acid as a percentage of total weight of the hop. Hops with a higher alpha acid content will contribute more bitterness than a lower alpha acid hop when using the same amount of hops. High alpha acid varieties of hops are more efficient for producing highly bitter beers. The term ‘India Pale Ale’ (IPA) was given to the beer that comforted the British people during the long trips they made to India via Africa. They needed a beer that would not spoil during the trip and the extra hops were added for this purpose. This is also why IPA beer is characteristically more bitter than other types of beer.

Preservation

Colorless bottles have always been in conflict with problems like light or heat, which cause hops to lose their bitterness. This is known as the formation of a compound called 3-methyl-2-butene-1-thiol (MBT), which is also found in the infamous secretions of skunks. The table below illustrates the extent of this problem and how it can be overcome.

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