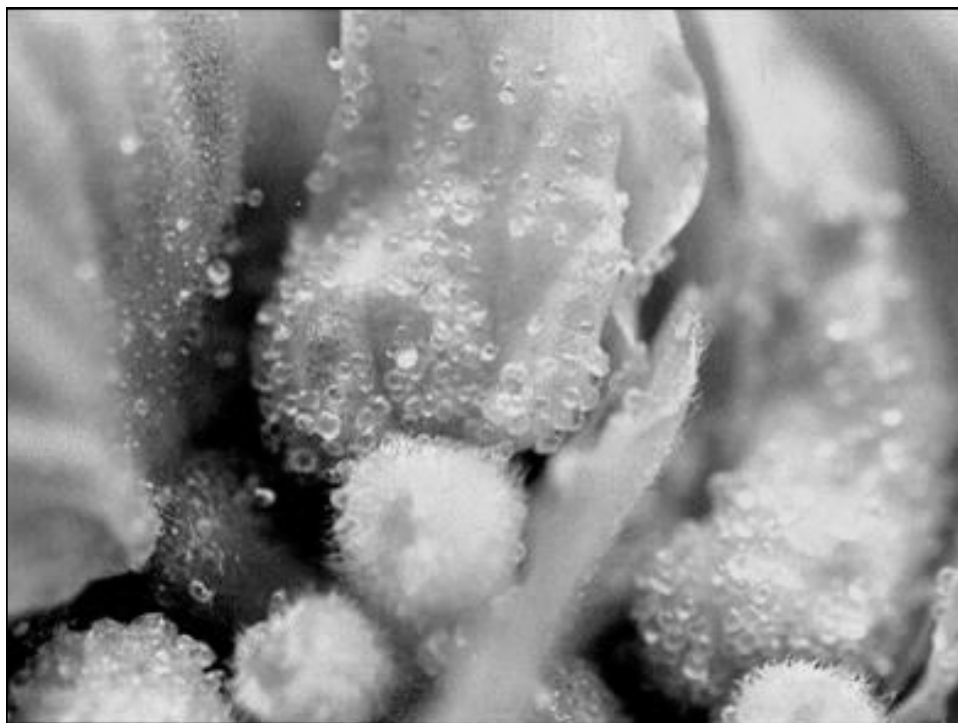




Nate Ferguson Niagara College



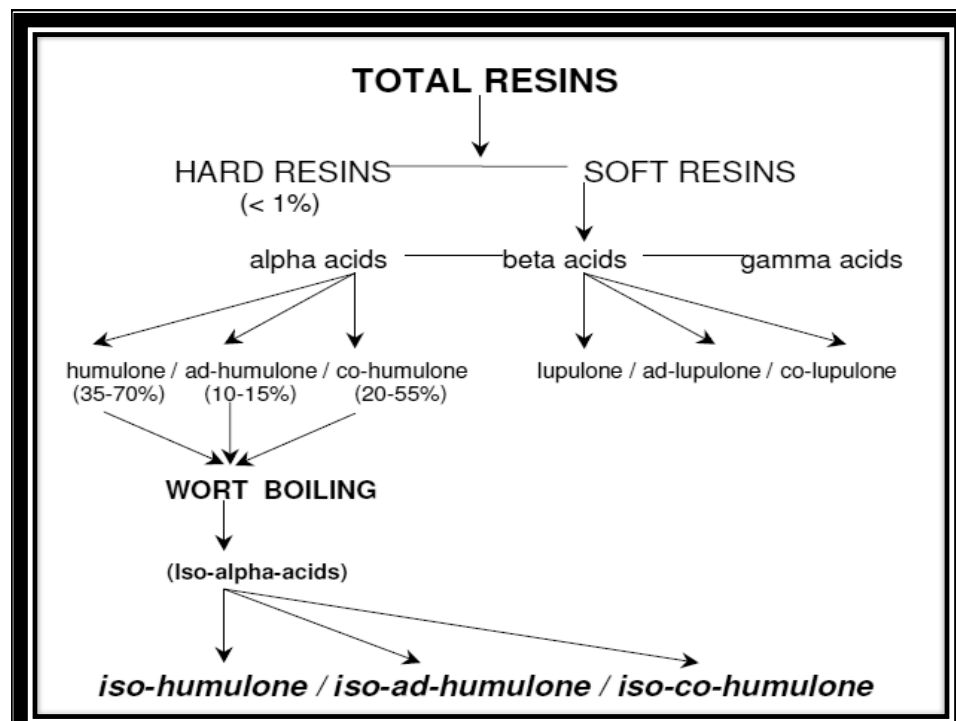
Hop Chemistry
from a Brewers Perspective!
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Three Fractions contribute to the entire brewing value of hops.

1. Total Resins
2. Essential Oils
3. Tannins

Fig. Breakdown of total hop constituents.



α -acids, β -acids and Bitterness



- Bitterness is one of the key flavour parameters of beer!
 - measured in International bitterness units (IBU)
- The bitterness is derived mainly from α -acids present in the hop resins
 - Present in dried hops at 2 – 19%
 - Presented to the brewer before purchase
- Most hop/hop products sold on alpha-acid content
 - May not be the only way (more coming!)

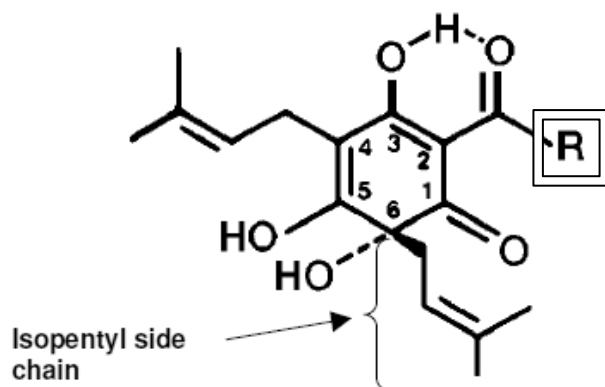
α -acids, β -acids and Bitterness



- There are several (possibly many) variations of α and β acids. Which differ from each other only in the side chain of the acid (**R**)
- As hops are stored over time, acid content decreases linearly
- If the hops are exposed to oxygen and warmer temperatures, oxidation of the acids can occur, lending a 'cheesy' flavor to older or ill-stored hops.

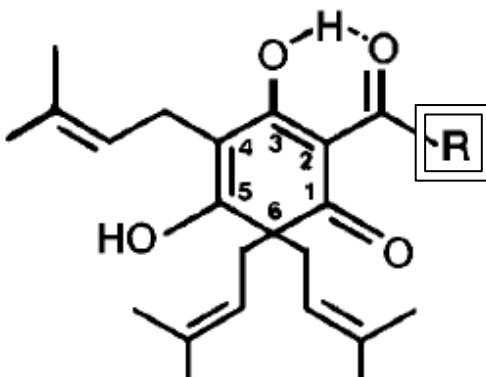
Alpha acids

The α -acids (Humulones) have the basic structural formula:

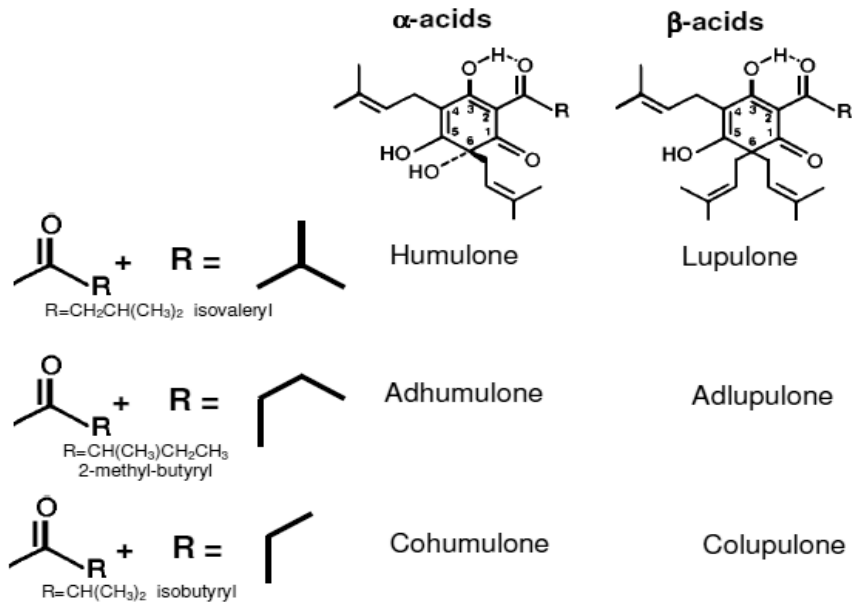


Beta acids

The β -acids (Lupulones) have the basic chemical structure:

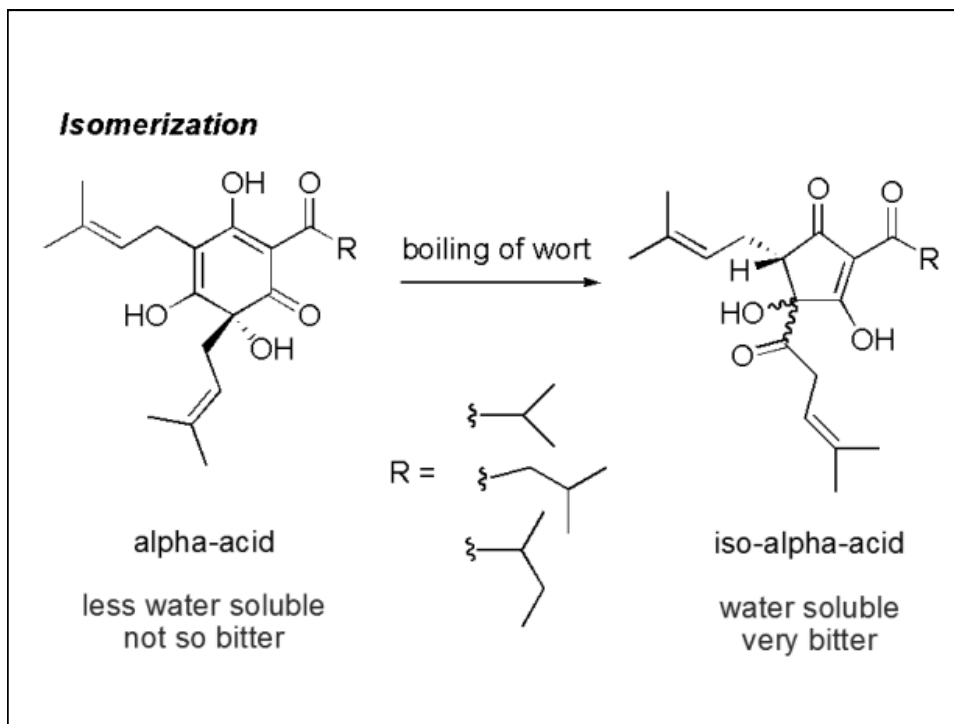


Three analogues each exist for the α & β acids.



Isomerisation

- The main bittering components from hops are α -acids, however bitterness is not provided in their normal form
- At normal wort and beer temp and pH, α -acids are insoluble!
 - hops are added during wort boiling to increase modify the acids and increase solubility!
- α -Acids (and to a certain extent B-acids) are isomerised (changed in shape) during wort boiling to produce iso- α -acids which are soluble in wort.



Break down the 3 main alpha acids

Humulone



- œ Is the most abundant alpha acid in most hops
- œ It is said to be a "soft" bittering hop!

CoHumulone

- œ Is considered to be a Harsh bitterness making it unpleasant!
- œ Is usually stated on hop spec sheets
- œ This "harsh" idea has recently been thought to be misunderstood as new high alpha varieties with high CoHumulone has proven to be clean!

Adhumulone

- œ Usually occurs in a minute amount; not well understood

Alphas? – The great divide!



- œ This is the point where Macro and Micro/Craft brewers split as we begin to look for different qualities from our hops
- œ Macro brewers are looking for alpha acids (Bittering potential) from their beer without much else
- œ Craft brewers are looking for hop flavour, aroma, mouthfeel, etc which are not associated with alpha acid content
 - œ They are associated with the Hop oil content!

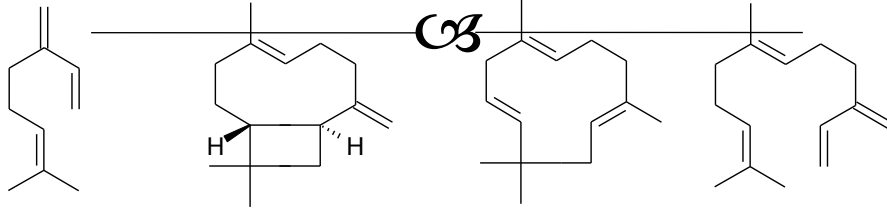
Hop Oils!



Responsible for the “nose” of hoppy beer
There are four main oils classically attributed to hops!

- œ Humulene
 - œ Primary oil responsible for “hoppy” nose
- œ Caryophyllene
 - œ Similar to Humulene and closely related to oils found in citrus
- œ Farnesene
 - œ Typically found in small amounts, has a grassy, green apple aroma (higher in some varieties like Sterling)
- œ Myrcene
 - œ Comprises the majority of the oil fraction, “no discernible aroma”

Hop Essential Oils



myrcene

caryophyllene

humulene

farnesene

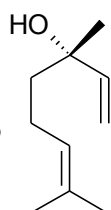
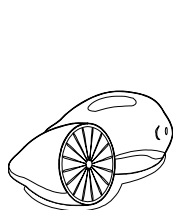
- Four major components of hop essential oil
- Account for 60-80% of oil for most varieties
- Amount & ratio vary (0.5% to 3% by weight of hop cone)
- Concentration of these oils are commonly provided to the brewer before purchasing!

New Hop Oils

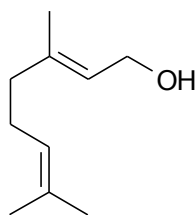


- œ The classical 4 oils are not the only hop aromas present
 - œ 20-40% of the rest of the oils to be composed of other volatile and potentially rich flavour potential!
- œ This area of hops is not well understood however it is something that several labs including we at Niagara College are hoping to shed some light on!
- œ The most common and well understood other oils are those that comprise the iconic American hop Pine/Citrus flavour!

The Pine/Citrus Flavour!



linalool



geraniol



e.g. Linalool - *clean, floral, citrus*

Geraniol - *floral, rose, fruity*





Oil Issues ~ Issues



- œ **Oils are very volatile**, heat sensitive, and susceptible to oxidative damage
 - œ Hops added early in the boil lose almost all of their volatiles!
 - œ oil losses range from 28-90% in six months at room temp depending on the variety
- œ For this reason “**Whirlpool/Late Hopping**” or “**Hop bursting/HopBack**” is common for craft brewers to keep as much hop flavour/oil in their beer as possible!
- œ Processing issues are also responsible for damaging oil profile

Late Hop/Whirlpool



- œ What is it:
 - œ We are adding hops near the end of the boil or while the wort is close to but not boiling
- œ What is different?
 - œ Isomerization of alpha acids (bittering) is low
- œ **Volatile oils are not evaporated at the same rate leaving more present in solution!**

Hopback Hopping



What is it:

- Running the HOT wort through a “filter bed” of whole leaf hops

What is different:

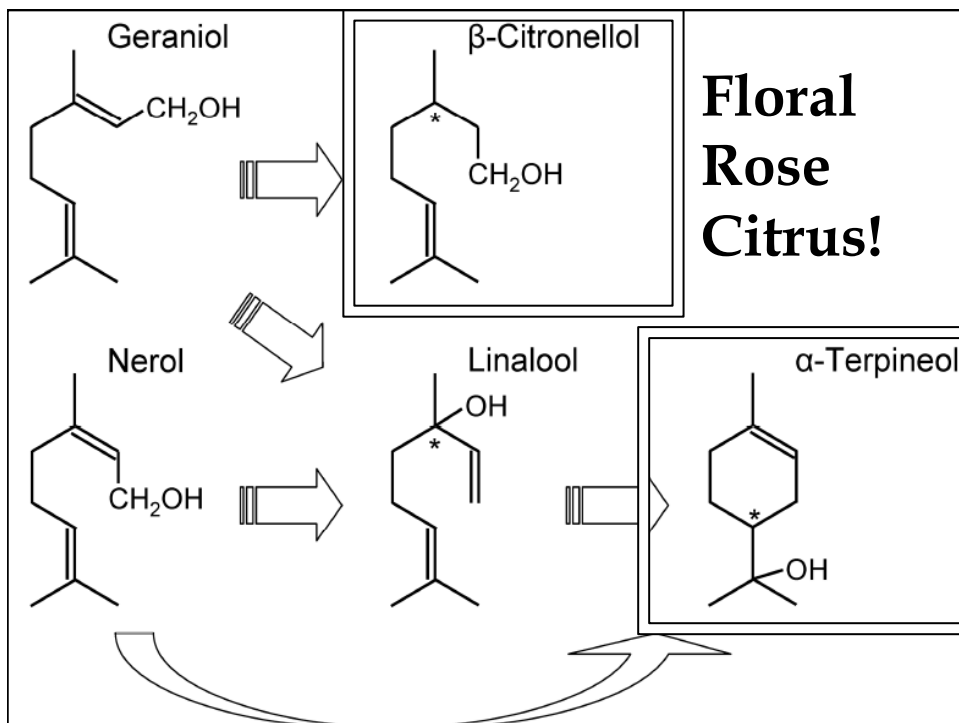
- Lupulin is undamaged as less processing has occurred
- Essential oils are fully extracted by wort**
 - Any oils that would normally be “flashed off” are recollected as the wort is cooled!

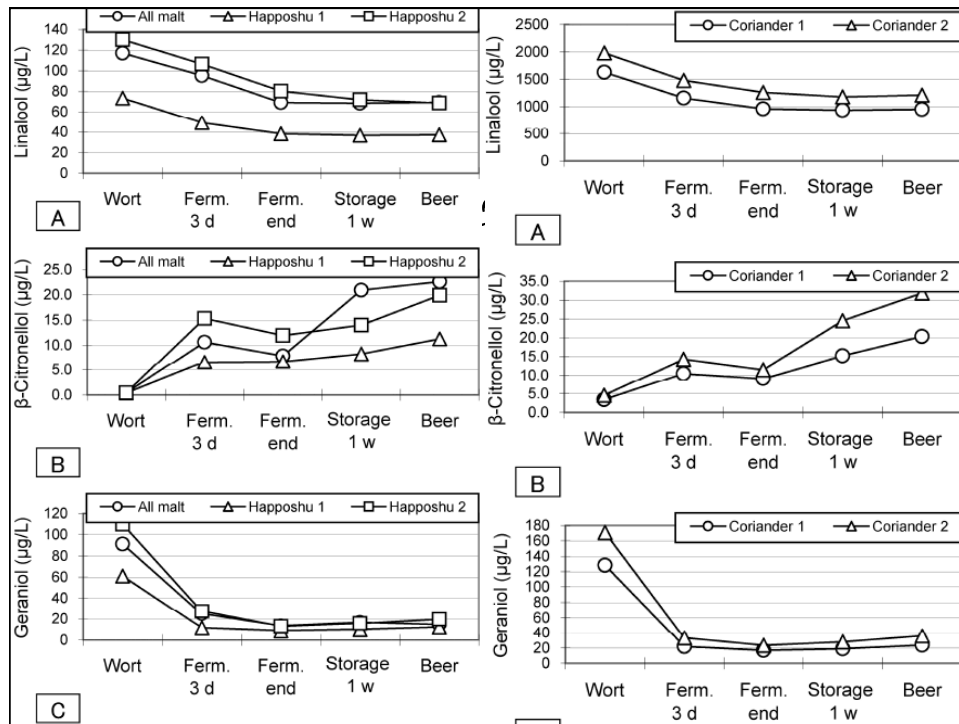


An odd increase in flavour!



- œ Active yeast has been shown to break down and alter some hop essential oils turning them into new oils and flavours!
- œ This is dependent on the hops in use however it occurs with all hops to a certain degree!
 - œ Is believed to be one of the main ways in which bottle conditioned beers remain fresh for long periods of time!
- œ Is not only an impact with hops. Spices such as coriander, vanilla, etc have shown to have compounds that are acted upon by yeast!





Dry Hopping ~ Should yeast be present?

☞ Citronellol = fresh citrus fruit!

☞ Alpha-Terpeneol: floral (lilac) with fruity overtone

☞ A component of lapsang souchong tea!

☞ Additionally

☞ Dry hopping the presence of yeast limits oxygen introduction via dry hopping

☞ This leads to an increase in flavour stability!

What we DO NOT WANT!

~Why do my hops smell like garlic?

- ❧ This is not a light struck or oxidized issue!
- ❧ When hops are left on the vine too long they begin to produce other compounds used for the defence of the plant!
- ❧ One of these compounds is known as Allicin and is commonly found in garlic!
- ❧ If hops are picked sooner this flavour will not be apparent!

Hop Varieties

- ❧ ***Bittering varieties*** - high resin content
e.g. Newport, Summit, Warrior (17-19% AA!)
- ❧ ***Aroma or 'Noble' varieties*** - high oil content,
e.g. Traditional English Fuggles and Goldings or German/
Czech Saaz, Belma, Citra, etc
- ❧ ***Dual purpose varieties*** - good mix of both resins & oils
e.g. Challenger, Mosaic, Columbus, centennial, etc

How can Teaching Brewery Niagara College Help?

- ☞ We are currently installing all of our equipment for our new lab (should be up and running in 1-2 months) which includes
- ☞ We will be fully equipped to determine
 - ☞ Alpha and Beta Acids Content
 - ☞ Hop Oil Composition and content
 - ☞ Hop Storability Index (HSI)
 - ☞ Many More
- ☞ We will be here to help assist and help grow the hop growers of Ontario!

How can Teaching Brewery Niagara College Help?

What we need from you!

- ☞ Tell us what type of analysis you want done?
- ☞ What time frame do you need it done by?
- ☞ When will you need your analysis done?
- ☞ What else we can do to help you?!



Thank You!



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