pH

What is it and how to measure it.

by Glen Napthali, Sept 2015

What is pH?

- pH is a measure of the acidity of a solution. It is a measure of the concentration of hydrogen ions (H^+; proton). The higher the concentration of hydrogen ions in a solution the more acidic it is and the lower their concentration the more alkaline it is.
- The formal definition of pH is the negative logarithm of the concentration of hydrogen ions

$$pH = -\log_{10}[H^+]$$

- Because the pH scale is logarithmic a one unit change in pH is a 10-fold change in the hydrogen ion concentration.

What is pH?

- An important law regarding the concentration of H^+ and OH^- is that the product of their concentrations has to remain constant. If the concentrations for H^+ and OH^- are written as negative logarithms (pH for H^+ and pOH for OH^-) their relationship is simply pH + pOH = 14.
- pH describes the balance between H^+ and OH^- ions. Another important aspect is how well that balance is maintained, this is referred to as buffer capacity.
- pH buffers are solutions that can resist sudden or gradual pH changes, to some extend as we will see, brought on by the addition of acids or bases.

How to measure pH

pH papers vs test strips vs pH meter

- Three viable methods of testing pH exists: pH paper, test strips and pH meters. In general the cheaper the means of pH testing the less accurate the result is.
- A simple pH indicator can be made from red cabbage juice, while this is great for illustrating pH indicators it has little practicality in brewing since the precision of pH readings is too low to be useful. This is an interesting experiment for anyone who is really interested.

How to measure pH

- A similar principle can be used with other dyes to develop pH papers and test strips, depending on the combination of dyes used different range pH tests can be made with varying degrees of accuracy.
- For the highest level of accuracy a pH meter is the best option, but they can be costly and need regular calibration and maintenance. Eventually the electrode will age, perform slower and need to be replaced.
- A pH meter has two electrodes which measure a mV potential this is converted into a pH reading.

How to measure pH

Temperature effect

- It is important to note that pH is temperature dependant, the temperature of the sample affects its H+ concentration and therefore its pH. This is the result of changing H^+ and OH^- dissociation balances in the sample.
- Most pH meters include automatic temperature compensation (ATC) which corrects for the effect of temperature on the probes response.
- Which temperature should I use? The answer is that any temperature works as long as it is noted and reported with the pH measurement. To make comparing of pH measurements easier it is best to take them at a standard temperature; 25°C or 20°C are common. Some brewers use their pH meter to test the pH directly in the mash. But testing hot liquids reduces the lifetime of the probe.

How to care for pH meter

Cleaning and care

- Always store the probe in pH meter storage solution recommended by the manufacturer and never in water even if it is distilled water. A pH meter storage solution contains salts that help the pH meter recover.
- Never let the probe dry out.
- Thoroughly rinse the probe with distilled or deionised water, after removing from the storage solution, between measuring samples or calibration buffers and before returning to the storage solution. A quick flick with the wrist also removes the excess water from the probe.

How to care for pH meter

- Move the probe around in the sample. This avoids localized pH changes caused by the acidic nature of the probe.
- Don't scratch or rub the glass bulb. It is coated with a sensitive layer that is integral to its function and it is rather fragile.

Calibration

- It is good practice to use two buffers covering the expected range of the sample, for brewing this is typically 4.00 and 7.00. Calibration should be carried out regularly. Especially when the probe has not been used for a while.
- Acceptable ranges for pH 7 buffer is +/- 15mV and for the slope –55mV/pH to –60mV/pH (or 95-102%)

What drives mash pH?

- Brewing range = 5.2 - 5.7 in Mash at room temperature (20°C).
- When grist and brewing water are mixed the mash will settle at a pH that is determined by the buffer strength and other pH characteristics of both the water and the grist.
- Darker grains will reduce mash pH, specialty grains more so. By buffering the mash pH higher you can counteract the reduction.
- Ultimately the Ca, Mg, and alkalinity will control the pH of the mash and wort.

Why does it matter?

Mash enzymes

- Mash pH is an important brewing parameter that lays the foundation for the pH of subsequent brewing processes and the final product. During the mash, a proper mash pH is important for optimal enzymatic activity.
- Mash pH will affect the efficiency and the flavours extracted from the grain, too high with a dark beer will produce more harsh astringent flavours.

Why does it matter?

Hops utilisation and beer flavour

- Wort pH influences hop utilization, hop flavor, wort color development, beer flavor, and the susceptibility of wort spoilage by microorganisms. Hop utilization is actually favored by high pH conditions (around pH 8) that simply are not found in a normal brew kettle.
- Hops contain tannins, which are astringent. If you have a high-pH wort and add hops to the boil as you normally would, the resulting beer is likely to taste very harsh.
- The higher-pH wort boil would also lead to significant wort darkening due to the Maillard reaction (browning).

Demonstration

- Hopefully this has worked.
- Two lots of water Glenorchy mains and Glenorchy mains with 0.4g/L $NaHCO_3$ added
- 0.4g/L $NaHCO_3$ should have raised the alkalinity to around 300 mg $CaCO_3$/L giving a residual alkalinity of 260mg/L.
- Each mini-mash has 150mL of water and 33g of crushed grain.

Useful references

- http://www.braukaiser.com/wiki/index.php
- http://www.hoptomology.com/2013/07/15/the-effect-of-ph-on-hop-character-the-results/

- **Calculators**
- http://www.brewersfriend.com/mash-chemistry-and-brewing-water-calculator/
- http://nomograph.babbrewers.com/index.html

- **How to Brew by John Palmer**
- www.howtobrew.com