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Title: *Refractometer Scales – misconceptions*

Refractometers can be equipped with a variety of scales to suit different applications. The most common scales are refractive index (the fundamental scale) and °Brix, which is used widely throughout the food industries. Both these scales are used for a large number of applications in both quality control/assurance and in research and product development. There are many other refractometer scales which can be and are used but there is often a misunderstanding regarding which scale should be used and what the scale actually means.

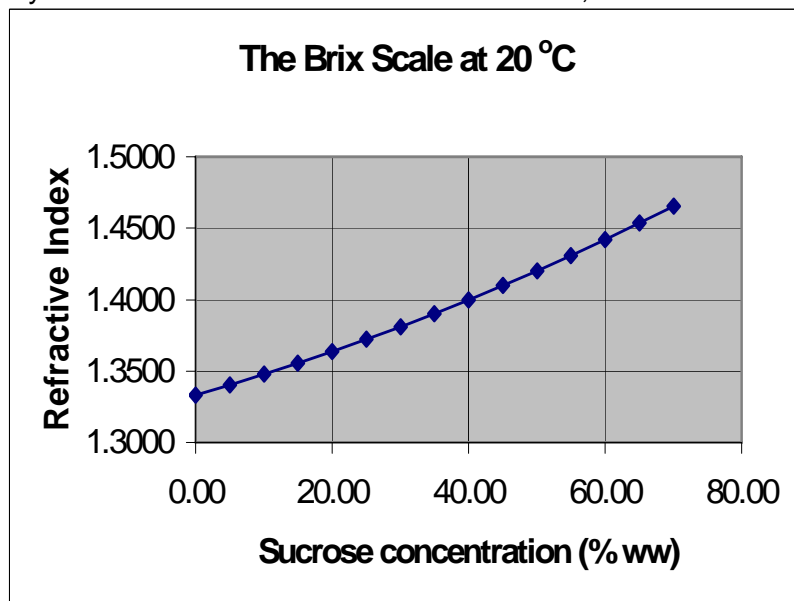
What is a scale?

A scale is simply a device for obtaining a relative measure of something. Scales usually relate to a physical property, such as refractive index or density, but often scales are devised for convenience. The refractive index scale is often not very meaningful and so other scales are devised which pertain to the actual measured quantity.

By relating a measured quantity to the refractive index of the test material, a user scale can be created. The most common relationship used is to relate the concentration of a chemical in solution to the RI of the solution. The best example is the Brix scale itself.

Brix – What is it? How is it used?

What is Brix? It is simply the name given to the scale which is based on the relationship between sucrose concentration



(%ww) and RI. Thus, the Brix scale can be used to measure the concentration of cane sugar (=sucrose) in water. A digital automatic refractometer actually measures the refractive index of the test liquid (sugar solution) and then uses an empirical equation programmed into its software to calculate sucrose concentration from the measured RI. A hand-held or Abbe refractometer often has the Brix scale provided on a graticule.

Brix is used generally as a measure of 'solids content' for the purpose of quality control. Many food and drink products have a 'Brix value'. This is because they are tested using a refractometer equipped with the Brix scale. However many users misunderstand what the 'Brix' of a product actually means. Most products tested using the Brix scale do not contain sucrose at all. The main exception is in the sugar industry – obviously! Even soft drinks that

are made from sucrose undergo 'inversion' (decomposition to form 50:50 fructose and glucose) caused by the acidity of the drink.

For pure solutions of sucrose in water, the Brix reading is an exact measure of the %ww dissolved sucrose. However, some people think that the Brix is a measure of % dissolved solids for all products. This is not true; for non-sucrose-based products, the 'Brix value' is simply a convenient relative measure of solids content but is not an exact %ww measure.

Simple illustration:

An 11.40% sucrose (Brix) solution has a refractive index of 1.3500. The same RI reading for a brine solution corresponds to 9.7% sodium chloride. To measure sodium chloride solutions using the Brix scale, a conversion table or equation relating sodium chloride concentration to sucrose (equivalent) concentration is needed.

The Brix of a product is, nevertheless, a very reliable parameter in quality control and is therefore used for this purpose.

Other scales

There are many, many possible refractometer scales that could be created, but in practice only a few are used. The Brix scale, as explained, serves as a general scale for quality assurance of many liquid food products. There are available other sugar scales such as glucose, fructose and invert sugar. These can be used by (typically) syrup manufacturers who wish to have an exact measure of dissolved solids for specific (non-sucrose) sugar solutions.

Salt scales (sodium chloride, artificial seawater) are used for checking brines, e.g. in fish farming. Ethylene and propylene glycol scales are used to check the concentration of antifreeze fluids. A % water-in-honey scale is used specifically by beekeepers to check moisture content of honey, which is a very important quality parameter. The wine and beer industries have devised quite a number of industry-specific scales for use with refractometers: Zeiss, Plato, Oechsle etc.

There are many, more specific examples of scales. B+S refractometers are equipped with software that allows the user to create their own 'user-defined' scale. An experiment is needed to measure the RI of a set of standard solutions of the chemical. These data are then used to determine a polynomial equation (B+S software) which can be programmed into the refractometer.

However, there is an important principle to appreciate....

Two components only!

If you wish to use a refractometer to measure concentration, it can only work in a two-component or binary system, i.e. chemical B dissolved in chemical A. If a third component C is introduced, then there are too many variables and a refractometer cannot be used to resolve the two unknown concentrations B and C. In such cases an independent measurement (not RI) is needed. If you remember simultaneous equations at school, you'll recall the general principle that for two unknowns, you need two independent equations to solve the problem.

The best example is in brewing of beer. During fermentation, there are two (principal) components present in the water: sugar and alcohol. As the fermentation proceeds, the sugar depletes and the alcohol concentration increases. At any time, the measure RI will not

be sufficient to calculate unambiguously both sugar and alcohol concentrations; there may be more than one combination that will give the same RI. However, by making an independent measure of specific gravity, using a density meter or hydrometer, a relationship can be used to calculate non-ambiguous sugar and alcohol concentrations. This method is used by many brewers.

Conclusion

Remember! A refractometer is not an analytical instrument – it cannot distinguish one chemical from another. It is a high precision measuring device that simply measures the refractive index of the test liquid – a single value. To convert this value into a meaningful quantity such as a concentration, other information is needed about the chemistry of the test material.

A simple scale will only work for a binary mixture. Thus the Brix scale will only provide exact %ww solids if you use it to measure pure solutions of sucrose in water.

Very often, a specific chemical concentration is not required for quality assurance. In a repetitive manufacturing operation it can be sufficient to measure a repeatable quantity such as Brix. Repeatability or precision (same thing) is what is important and this is what a refractometer can provide.

Any concentration scale can be created for a refractometer provided you have the data but the Brix scale can, in fact, be adapted to all sorts of liquid QA problems.