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Digital Refractometers – Universal Concentration Meters

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By Angelo DePalma, Ph.D – Partial Reprint – Originally Published April 6th, 2011, for original see Lab Manager; – Refractometers are instruments that quantify and identify chemicals and materials based on their refractive index (RI). A unique property related to the speed of light as it passes through a substance, RI (Refractive Index) is defined as the ratio of the speed of light in a vacuum relative to its speed in the test material.

For example, the RI of pure water is 1.33, meaning that light passes through a vacuum 1.33 times faster than it does through water.

Since light also changes direction as it passes from one medium to another, RI is conveniently measured as a function of this unique "angle of refraction". Everyone is familiar with how a partially submerged stick seems to "bend"as it enters water. Refractometers quantify RI by measuring the angle formed by light as it leaves air and enters the test object.

Priced to fit the job

Refractometers range in size and capability, from handheld units costing a few hundred dollars to full-featured instruments in the $10,000 to $15,000 range. Handheld models may be of "traditional" or digital design; higher-end instruments operate on a bench-top or, in some industries, in-line to monitor manufacturing processes.

Refractometers are priced to fit the job and the value of what is being analyzed. A truck driver uses a $200 handheld visual refractometer to check the water content of an ethylene glycol coolant, while a top -of-the-line bench-top unit may be used in food, chemical or pharmaceutical quality testing.

Refractometry is one of the most versatile analytical techniques. Pure substances that transmit light have unique RI's that change as the concentration of additives changes. For example, the RI rises with increasing sugar concentration since sugar molecules dissolving in water slow light down as it passes through.

As a "universal concentration meter", refractometry serves a range of industries; water treatment, chemistry, biology, foods, beverages, brewing and viticulture, paints, lubricants, personal care products, pharmaceuticals, and many others. Manufactures routinely use RI to check incoming raw materials as well as complex products used in manufacturing, research and development.

Refractometers in constant use must be maintained, primarily by cleaning the prism. If this in not done after every test, fluid from the previous run will evaporate, leaving the solute on the prism and distorting the next measurement.

"Cross-contamination between samples is another source of error," observes Richard Spanier, sales and marketing director at Rudolph Research Analytical (Hackettstown, NJ). Rudolph Research specializes in bench-top refractometers priced in the $10,000 to $14,000 range.

Protecting the sample using measurement is another precaution. volatile liquids like alcohol evaporate, which distorts the concentration, while hydroscopic liquids like glycerol can dilute if they pick up water. "You also want to make sure there is no temperature gradient across the sample.", Mr. Spanier warns, since RI is a function of temperature.

No detailed analysis

Unlike spectroscopy, RI is not diagnostic or conclusive for a particular ingredient-a sugar-water solution may have the same RI as a saltwater solution (albeit at different concentrations). RI is most appropriately applied when analyses are known, or when the RI of a finished product has been previously established.

Analysts regard refractometry as a quality tool, or screen, for determining if a product is within specifications. Batches displaying an out-of- spec RI can be further tested with more precise techniques such as HPLC in order to investigate where the process went wrong. Or, refractometry may be combined with other physical methods such as densitometry, or polarimetry to provide deeper insight of a product.

For example, a manufacturer of apple juice or maple syrup knows that its product is suitable for sale if the RI falls within certain boundaries, with out having to quantify every component. The producer resorts to more complex analytics only occasionally, or when the RI falls out of spec.

as Noah Radford, a technical specialist at Atago U.S.A. (Bellevue, WA), puts it, "Unlike HPLC, RI provides rapid identification, not a detailed analysis."

What to look for

"For big users of refractometry, performance is a major factor because it's a tool they use every day", says Mr. Spanier. "People who buy on price are probably first -time buyers." Next, he says, the manufacturer's reputation is perhaps the single most significant factor in choosing a refractometer. "If an instrument will be sitting in my lab for fifteen years, I want quality."

Noah Radford says users should carefully consider the composition and value of what they seek to measure, the measurement accuracy required, and the cost of an incorrect analysis. "Also consider the testing environment, temperature and humidity conditions, and whether you're measuring in a controlled laboratory setting or on a manufacturing floor."

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