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Refractometers: Innovating Around the Edges

Refractometers: Innovating Around the Edges

By Angelo DePalma, Ph.D – Partial Reprint – Originally Published January 20 2012, for original see Lab Manager;
Refractometers are analytical instruments that measure the refractive index (RI) of liquids. Physicists define RI as the ratio of the speed of light in a vacuum divided by its speed through a test medium. Any substance that is denser than a vacuum – pretty much anything – will have an RI greater than 1. The RI of pure water is 1.33, which means that light passes through a vacuum 1.33 times as fast as through water.
A recently completed survey by Lab Manager Magazine indicated that the most common industrial applications of refractometry were medical (34 percent), food/beverage (28 percent), chemicals (19 percent), and academia or research (15 percent). Of all the features and factors entering into the refractometer purchase decision, price was "very important" to 97 percent of 273 respondents.
Depending on the solute, adding materials to water causes the RI to rise or fall above 1.33. Salt and sugar raise RI in a linear, concentration-dependent way, while alcohols like methanol and ethanol lower RI, since they are less dense than water.

Refractometer: Pluses and minuses

Refractometry brings several benefits as an analytic modality: Instruments are simple and relatively inexpensive, measurement is rapid, and quantitation is highly accurate.
On the negative side, refractometry brings value only when the constituents of a solution are well-known. It is possible to formulate two solutions, one sugar and the other salt, with exactly the same RI. In fact, one could mix and match a dozen constituents to reach the same RI value. If a solution contains only sucrose, an analyst can measure a very wide range of concentrations from an appropriate calibration curve. But if a second constituent is also changing, all bets are off.
Refractometers are limited in other ways as well. Unlike some other analysis types, refractometry is not sensitive enough to pick up partper- million concentration differences. And if special care is not taken to hold all but target analyte concentrations constant, concentration changes of a high-RI ingredient or impurity may swamp out the response from the target. On the other hand, if two or more constituents re main constant but the sugar changes, a suitable curve may be constructed for that solution.
Since all solute materials have unique mass and optical spectra, and quite often different chromatographic retention times, refractometers are often employed with other instruments. Polarimeters or densitometers are instruments that also provide concentration- type readouts without specifically identifying what is in the sample.

Refractometers; Format and function

While refractometers lack the granularity of analysis of other instruments, they are quite versatile in terms of format. Refractometers are available as handheld, benchtop, and in-line (or bench) units. Stationary lab refractometers are the most accurate and versatile but are best kept out of harsh environments, while handheld or field instruments bring the instrument to the analyte. Analysts and production engineers use in-line refractometers, which are also stationary, to monitor process liquids in real time.
"All three types have their benefits and drawbacks," says Noah Radford, technical specialist at Atago (Bellevue, WA), "but handheld units are the only way to go for someone taking measurements at multiple locations."
In-line refractometers are normally associated with process industries (chemicals, foods, pharmaceutical, biotech), but the same company may use all three refractometer types, depending on the situation. For example, metalworking companies may have 150 machines on a large shop floor, each requiring cooling fluid. Workplaces with a centralized coolant sump will benefit most from an in-line refractometer that monitors the common cooling fluid in real time. Where every machine has its own coolant reservoir, the most appropriate solution is a handheld refractometer. "It's impractical to take samples from all those machines and bring them back to a benchtop unit," Mr. Radford says.
Similarly, a pharmaceutical company may employ handheld refractometers to provide a quick identity scan for incoming raw materials, an in-line unit to monitor composition during the formulation of a fermentation nutrient medium, and a benchtop model to quantify salt concentrations in a cell culture buffer ingredient.

Digital Refractometers are moving Toward "Smart" Refractometry

Richard Spanier, sales and marketing director at Rudolph Research Analytical (Hackettstown, NJ), notes that instrument-related errors in flat-prism refractometers arise from improper cleaning or inappropriate application of analyte to the prism surface. Instrument makers compensate for such variability through "smart" features that detect trapped air bubbles or smudges.
Another source of error is poor temperature control, which can cause not-so-subtle changes in sample composition. Some analytes, like volatile organics, evaporate quickly above ambient temperatures, while others (e.g., salt solutions) are hydroscopic. Analysts did not appreciate the impact of temperature until quite recently, according to Mr. Spanier. Many top instruments today feature Peltier cooling; Rudolph's latest laboratory refractometers also employ a technique whereby samples are heated or cooled from above and below.
"Just as automobile companies are developing smart cars, instrument makers are constantly adding 'intelligence' to refractometers," Mr. Spanier says. "The goal is to reduce erroneous results and rework."
For additional information about selecting a Refractometer for your application see Rudolph Research Refractometers