Polymer Quality Control: Real-Time NIR Testing Cuts Cost up to 90%

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When using Near-Infrared (NIR) light measurement devices, use the right tool for the job whether for moisture, composition analysis, or full spectrum testing

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In manufacturing plastics, rubbers, elastomers, and adhesives, it is critical to monitor polymerization processes for quality and cost at every production stage from material receipt through final inspection. Polymers have a range of characteristics and can be constituted into forms such as sheets, films, foams, filaments, powders, and PET bottles.

Whether polymerization is bulk, solution, suspension, or emulsion, gathering essential data can help to prevent costly quality issues. Otherwise, internal production failures can require rework or scrap; and external failures can lead to warranty claims, recalls, and even potential liability.

Globalization has further put an emphasis on cost cutting to compete on price or quality and performance that meets very tight specifications. Either way, measuring key production parameters effectively and efficiently is crucial to the success of the process.

While traditional testing is critical in determining polymerization factors from simple moisture content to complete chemical analysis, it is time consuming, labor intensive, and has substantial ongoing costs in terms of the purchase and disposal of consumables such as reagents and chemicals. Conventionally, it requires sample preparation, and can take 5-15 minutes for moisture testing and 24-48 hours for more complex chemical testing.

Fortunately, an approach using NIR spectroscopy can now provide immediate, real-time laboratory quality readings via a non-contact, secondary measurement method that can deliver moisture, composition analysis, and even full spectrum readings for a fraction of the running cost of conventional methods.

"Real-time NIR measurement enables continuous monitoring and optimization of
polymerization processes," says John Bogart, Managing Director of Kett US, a manufacturer of a full range of moisture meters, composition analyzers, and full spectrum testing equipment. "It provides more timely quality assurance data than a team of QA people using traditional testing methods and 100% of product can be inspected." Instant testing enables superior quality control and immediate adjustment if a process starts to drift out of the target

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range. The results can improve batch consistency and yield, while helping to eliminate batch failure and reduce material waste.

Bogart explains that NIR spectroscopy bounces beams of light off a solid, slurry or liquid and measures how much light is absorbed in certain electromagnetic spectrum wavelengths [about 700-2500 nanometers]. This produces an "optical fingerprint" of the sample, with the device calculating the desired measurements after the meter has initially been calibrated to a lab or production standard.

Because NIR spectroscopy eliminates the cost of buying and disposing of consumables like reagents and chemicals as well as the need for QC specialists doing the testing, the approach produces superior results at up to 90% savings in running costs. The equipment can be handheld, desktop, online or inline and is versatile enough to work inside mixers, blenders, extruders, pneumatic and vacuum transfer lines as well as pipe-flow applications when utilizing fiber-optic accessories.

However, despite the benefits of NIR testing, not all polymer manufacturers need to use the most sophisticated and costly devices for every application.

"Don't pay for a Lamborghini if you need a Ford, or a Ford if you need a Lamborghini," says Bogart. The point is that polymer manufacturers do not need to pay for a more expensive full spectrum machine if only moisture measurement, or composition analysis, for example involving moisture and oil and/or solvent, is necessary.

"For many polymer applications, a moisture meter is all that is needed," says Bogart. "A composition analyzer is a step up; and a full spectrum machine goes beyond that when even more comprehensive or specialized testing is required."

To help polymer manufacturers optimize quality at the lowest possible cost with NIR technology, we will examine the various options.

Choose the Right NIR Equipment for the Job

NIR devices fall into two general categories: Filter-Based and Full Spectrum.

Filter-Based
NIR filter-based products block visible light and only allow certain wavelengths of infrared light to enter the device. According to Bogart, filter-based products, which include moisture meters and composition analyzers, are simpler than full-spectrum devices because they work with a limited range of wavelengths. However, the devices have some advantages.

"Filter-based products are less expensive, easier to calibrate and maintain. The devices are also more robust and typically more stable for operators to use. The drawback is that the instruments are more limited in what they can test," says Bogart.

Moisture Meters
Traditionally, a slower method of measuring moisture is a Loss on Drying test, which measures the total material weight change after drying. However, such tests typically require a sample to be prepared and brought back to the lab. The test takes at least 15 minutes to several hours to perform, which is too slow when more immediate measurements are required. It also requires the sample to be altered or destroyed.

As an immediate, real-time alternative, NIR moisture meters are the simplest and most economical type of filter-based device. Often, NIR moisture meters are used to inspect incoming raw materials. However, the meters can be used anywhere in the production process where achieving a specific moisture content is important. With the devices, reflected light is filtered to a narrow portion of the Near-Infrared light spectrum, usually at only one or two wavelengths.

Often, bulk polymerization as a process does not require much more than a moisture meter for testing, since the reaction proceeds without a solvent, diluent, etc. However, moisture meters can be utilized with more complex forms of polymer where the client may want to measure moisture anyway.

Bogart relates an example of a polymer manufacturer that uses a NIR moisture meter to successfully produce pellets for a medical device company. The medical device company creates products that are inserted into the body. For this application, the polymer manufacturer needs to have extremely low moisture in the pellets before using an injection mold to create the part. If the moisture level rises above a certain amount, the mold process does not work well, which increases the part failure risk.

"The polymer pellets must be precisely made and properly packaged with very little moisture; and the samples cannot be destroyed during verification," says Bogart. "So, the manufacturer uses NIR moisture metering to cost effectively ensure that 100% of polymer pellets safely meet the required criteria."

Composition Analyzers

Among filter-based devices, NIR composition analyzers are a step up in measuring capability, and usually can simultaneously measure a few different chemical components in the polymer while being limited to about 6-7 wavelengths of light. In addition to moisture, the devices may also be used to measure residual oils or solvents, which can cause contamination issues if not detected and removed.

In the polymer industry, solution polymerization which is conducted with an inert solvent and initiator, may find a NIR composition analyzer helpful for monitoring and adjusting the process.

Bogart points to another common use of such a device. "The industry often uses recycled plastic as a raw input, but does not always know where it comes from. So, manufacturers may want to measure total oil and solvent in addition to moisture, since any residual contaminants can disrupt the process and even cause a plant malfunction," he says.

A third traditional use of this type of device is to measure coating thickness or film thickness. Both desktop and real-time online process measurements can be provided in many cases. Generally, the price point of the NIR composition analyzer is substantially lower than alternative technologies.

Because polymers are so widely used in a variety of industries, Bogart notes that composition analyzers are often used not only on incoming materials, but also on in-process materials, final products, and even on external product failures and returns to help determine the cause of the problem.

Full Spectrum Testing

In contrast to filter-based devices, NIR full spectrum devices may measure 500+ wavelengths to determine if certain substances or materials meet a wide range of criteria.

With full spectrum testing, the widest number of targeted factors can be measured in real-time, once the device is specifically calibrated for their detection. In addition to moisture, for example, polymer manufacturers may often measure density, viscosity, melt flow rate (MFR), and functional groups.

Such testing is commonly utilized during emulsion polymerization, which are used to produce latexes and synthetic polymer colloids for paint, coating, rubber, binder, and adhesive applications.

The testing is also helpful for successfully carrying out suspension polymerization processes, which are often used to produce polymer beads. Such processes generally

involve an initiator and comonomers, with the final polymers suspended in an aqueous phase containing additives and residual monomer.

"For quality control, manufacturers may need to monitor many chemical reactions during the polymerization process to bring it to the desired endpoint," says Bogart. "For instance, several different chemicals may cause a chemical reaction that transforms them into a blended product. In such cases, manufacturers can optimize the quality and speed of their process with NIR full spectrum testing to ensure that everything produced is completely finished product with no residual chemicals left over."

Traditional direct measurements of these parameters can take up to 24-48 hours for results. The tests are very complicated, since various substances must be broken down into their underlying chemical compositions. The tests require meticulous set up and conducting to avoid errors. Other tests, such as viscosity and functional groups, may be carried out as well, with each test requiring additional time and staff members.

In contrast, full spectrum NIR testing is instant and can produce results in real-time without relying on laborious, error prone techniques. Such real time monitoring of the polymerization process can give the manufacturer the ability to make immediate adjustments to optimize the process, if necessary, when the process is starting to drift. This can result in dramatic improvements in batch-to-batch quality and consistency as well as overall product yields and energy usage.

While polymer manufacturers are more familiar with traditional methods, for those concerned not only with quality but also profitability, selecting the NIR approach that works best for the application - whether moisture meter, composition analyzer or full spectrum tester - can have a major impact on the bottom line.

For more info, contact Kett: call 800-438-5388; email support@kett.com; or visit www.kett.com.

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