Application Note

Keywords

- Plastic tubing
- Opacity
- Thin film deposition

Techniques

- Transmission spectroscopy
- UV-Vis-NIR spectroscopy

Applications

- Quality control
- Coating characterization

Measuring the Opacity of Plastic Tubing with Vis-NIR Transmission Spectroscopy

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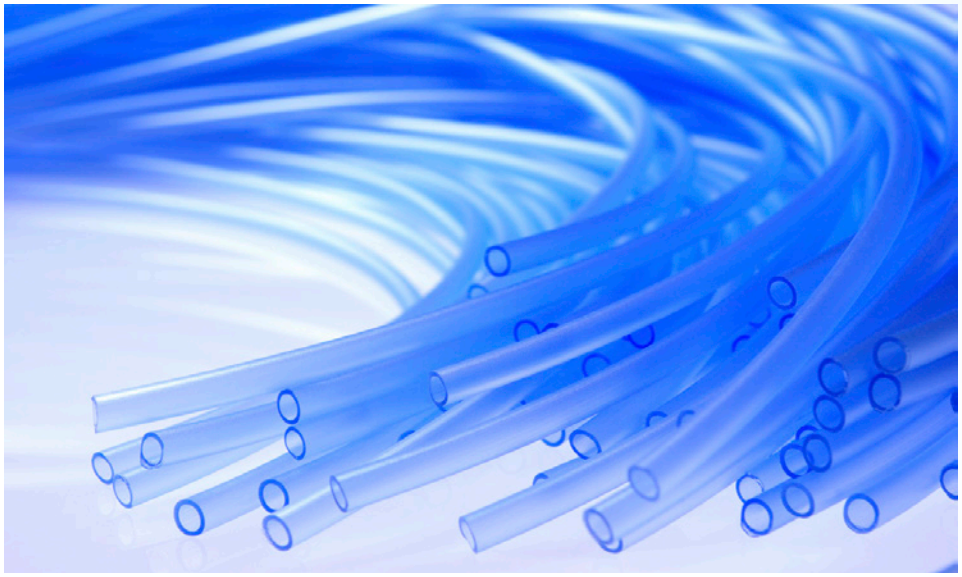
Plastic tubing is available in a variety of opacities ranging from clear to translucent. The transparency of plastic tubing is varied for reasons such as providing contrast for visual monitoring of fluid flow, decreasing exposure to ambient light, and making the tubing more distinct for machine vision technology. In this application note, Visible-NIR transmission spectroscopy is used to assess the amount of frosting applied to plastic tubing to determine if the tubing meets the required opacity level.

Background

Plastic tubing is used everywhere – from the beverage dispenser at your favorite restaurant to the gas and liquid delivery lines in life-saving medical devices. Whenever fluid transport is required, some type of plastic tubing is likely involved. In addition to varying plastic formulations for transporting materials as different as inert biological fluids and corrosive slurries, tubing sizes and shapes are available to meet virtually every fluid delivery need.



In many applications employing plastic tubing, visual contact with the flowing material is required to confirm flow and check for bubbles. Visual monitoring is facilitated by enhancing the contrast between the fluid and plastic tubing. Coatings, frosting and other surface modifications are used to vary the interaction of light with the tubing, making it easier to observe fluid flow. For example, less transparent, more translucent tubing is used to provide contrast and reduce photodegradation caused by exposure to ambient light. Also, the ability to distinguish plastic tubing is becoming more critical as robots and vision technology are used to automate work.

Modular spectroscopy components can be used to assemble a range of setups to measure the interaction of light with plastic tubing. In the case of frosted tubing, where light transmission must be kept within a narrow range to provide the desired tubing characteristics, Vis-NIR transmission measurements provide a straightforward method to assess frosting level. In this application note, the frost levels for several samples of plastic tubing were assessed using Vis-NIR transmission measurements. Samples with too much or too little frosting were labeled as rejects.

Measurement Conditions

Five plastic tubes with varying levels of frosting were used for the analysis (Figure 1). Details on the frosting level for each sample are provided in Table 1.

Table 1: Frost Level Analysis of Plastic Tube Samples

Sample	Status	Reason for Rejection
0	Reject	Excessive frosting
1	Pass	NA
2	Pass	NA
3	Reject	Insufficient frosting
4	Reject	Insufficient frosting
5	Reject	Insufficient frosting

Transmission measurements were made using a USB2000+VIS-NIR-ES enhanced sensitivity Vis-NIR spectrometer covering the range from 350-1000 nm, an HL-2000-FHSA tungsten halogen light source, a STAGE-RTL-T reflection/transmission stage and two QP400-2-VIS-NIR 400 µm optical fibers.

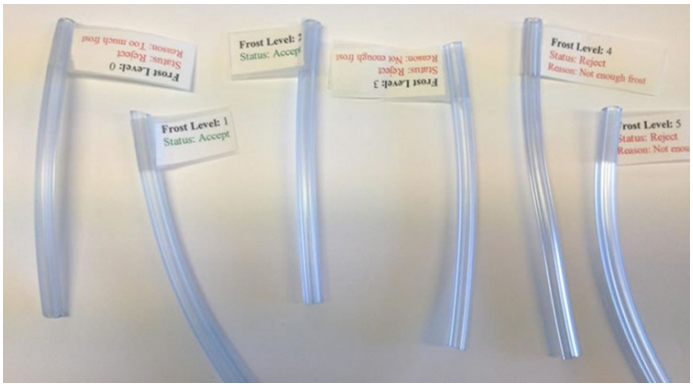


Figure 1: Although differences in the frosting levels of plastic tubing samples are difficult to distinguish visually, spectroscopic methods are highly reliable in characterizing tubing properties.

The tubes were placed between the two collimating lenses of the transmission setup and adjusted until the most reproducible orientation was found. To ensure accurate results, a more repeatable measurement method and a sample holder to accommodate the round tubing are recommended. The sample holder should always measure the tube in the same position.

Results

The transmission spectra measured for the frosted plastic tubing samples are shown in Figure 2. The transmission intensity measured for these samples correlates with the frost levels reported for the plastic tubing in Table 1.

The plastic tubing sample with the lowest transmission (Sample 0) is rejected due to low transmission caused by frosting levels higher than the passing tubing sample. The plastic tubing samples with the highest transmission (Samples 3, 4 and 5) are rejected for high transmission due to insufficient frosting on the plastic tubing. Note that even though the transmission intensity for Samples 1, 2 and 3 is very similar, the transmission spectra are sufficiently different to reject Sample 3 as having insufficient coating.

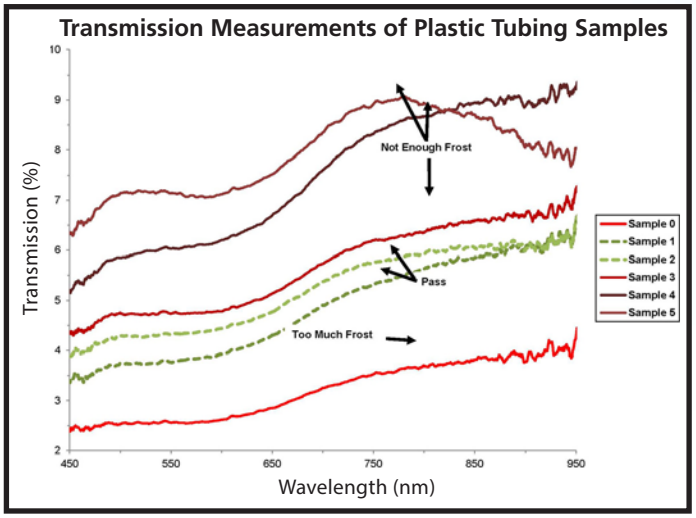


Figure 2: Transmission characteristics of plastic tubing samples varied by the amount of frosting applied to the surface of each sample.

Visual observation of the plastic tubing samples showed that the frosting level for each sample was difficult to distinguish (Figure 1). This underscores the value of spectroscopic transmission measurements to discriminate plastic tubing with very similar frosting levels.

Conclusion

The power of Vis-NIR transmission measurements to discriminate tubing samples is demonstrated by the different transmission intensities measured for plastic tubing samples with similar frost levels. The ability to discriminate samples separated by less than 1% transmission make this technique a good candidate for use in QA or QC methods to ensure the plastic tubing has the desired light interaction properties and characteristics.

The use of transmission spectroscopy described here is just one of many applications where this type of measurement can be used. Miniature UV-Vis-NIR spectrometers can be configured to measure coatings that are applied to other transmissive samples including optical filters, polymer films and lenses.

The availability of spectral data over the UV-Vis-NIR range (~200-2500 nm) enables extensive coating characterization well beyond transmission at a single data point. What's more, with the modular spectroscopy approach, the instrumentation is robust and flexible enough for use beyond the laboratory setting, from integration into other analytical devices to installation on a process line.

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