Technical Note

How to Measure: *Translucent Materials*

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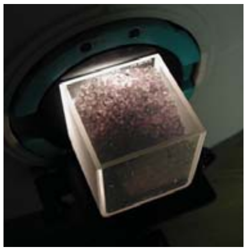
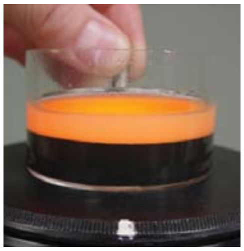
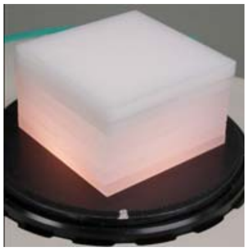
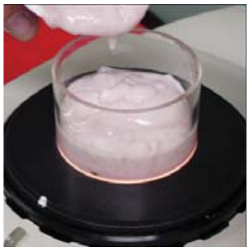
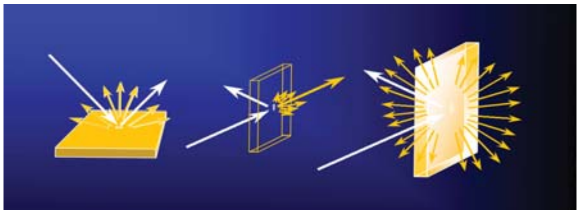






Translucent materials offer a significant color measurement challenge since they interact with light in far less controlled manner than most other materials. The color of a material is calculated from measurements of its relative spectral reflectance or transmittance. When light is incident on an opaque non-metal or metal surface, the first surface interaction determines the corresponding perception of gloss and color. Similarly, for transparent materials, light reflected at the first surface is responsible for the perception of gloss, while light transmitted straight through the material gives the color. Translucent materials have both opaque and transparent characteristics. Some incident light reflects off the first surface as gloss, while some enters the material and undergoes multiple scattering and light trapping within the material, resulting in a diffuse pattern of reflectance. In a second interaction, light is scattered and transmitted through the sample, emerging on the other side in a diffuse pattern. As a result, color can be seen in both diffuse reflectance and transmittance, depending on how the sample is viewed.



The CIE standard geometries used in bi-directional (45/0) and diffuse sphere instruments are well defined, and were developed for solid opaque and transparent materials. Measurements on opaque materials in 45/0 geometry or using a sphere in specular-excluded mode are sensitive to effects of first surface roughness and colorant absorption. Using a sphere in specular-included mode negates first surface roughness, and measurements are then sensitive primarily to colorant absorption. Similarly, measurements of total transmittance for transparent materials using a sphere instrument tend to negate slight scattering of the transmitted signal, yielding a robust measurement of colorant absorption. Measurements made in regular transmittance mode are sensitive to both scattering during transmission and colorant absorption.

For translucent materials, there is no standard geometry. Instead, the general rule is to make translucent samples thinner or, more commonly, thicker and to make measurements as if they were effectively transparent or opaque. This principle can be applied to a wide variety of translucent applications including powders, pellets or granules, sheets, semi-solids, and translucent and near-clear liquids.

Loose powder does not transmit light diffusely, so technically it is considered opaque rather than translucent. However, in the loose form, it does trap light similar to the translucent samples, and there are a two basic techniques for dealing with this. The most consistent method is to press the powder into a plaque using a defined quantity and consistent pressure.


Alternatively, a loose powder can be measured through the bottom of a glass sample cup with a couple of taps of the cup on a hard surface to tighten up the powder. The absorbance effects of the glass window are a constant in the measurement.

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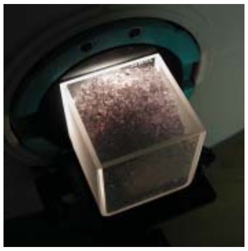
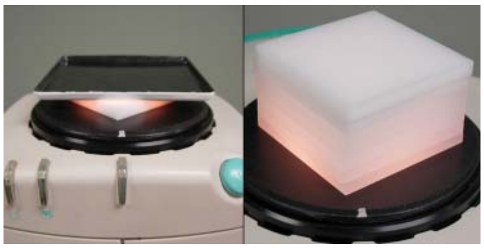
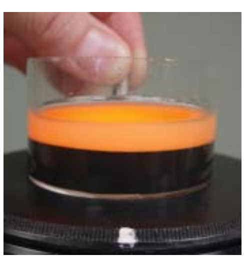


Pellets or granules can be made effectively solid by measuring through a glass window, and effectively opaque by increasing the thickness of the sample to simulate infinite path length.

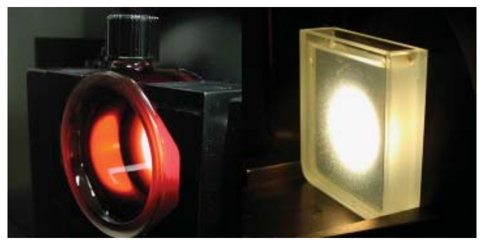


Translucent sheets can be thinly sliced and measured in transmission. However, it is more common to stack a number of sheets together ('back like-with-like'), making the sample stack effectively opaque. A weighted backing is generally used to help maintain uniform pressure and minimize flexing. Reproducible results can be obtained by cycling through the stack using the largest area of sample view possible and averaging the readings obtained. An alternative technique is to measure a single translucent sheet backed by a uniform material such as a white tile ('back like-with-white'). This technique is only suitable for comparative measurements since the absolute values obtained are dependent on both the translucent sheet and the white backing tile.



Translucent liquids, such as milk, can be measured using the 'ring-and-disk' technique. The liquid is measured through the bottom of a glass cup to establish a fixed measurement plane and a 10 mm thick black ring is placed in the cup to establish a consistent path length of sample and prevent ambient light from entering from the sides. The cup is filled with the translucent liquid to a level above the ring and a white disk floated down to sit on top of the ring. The white disk provides a non-spectrally selective background to reflect any light transmitted through the sample back to the detector, and allows comparative measurements to be made.

Semi-solids like creams or sauces are liquids with high solids content. They can be made effectively solid and opaque by measuring through a glass cup (bi-directional 45/0 geometry) or cell (sphere geometry). Averaging multiple readings across a number of samples (using the same glass cup or cell) is recommended, particularly if the material is non-homogenous.



For a **liquid sample with high solids content,** like coatings, the effects of high scattering can be accommodated by measurement using a thin path length cell (typically 2 mm or less) on a sphere instrument in the total transmittance mode to collect the highly scattered light. For a **liquid sample with low solids content,** having slight scattering, the same technique with a 10 mm path length cell works well.

Even with the good practice recommendations given above, single instrument repeatability and inter-instrument reproducibility will be higher for translucent materials than other materials. This is due to slight variations in the optical path of the instrument interacting with the light trapping characteristics of a translucent sample ('translucency effect'). Optimum reproducibility is obtained if measurements are made using the same model of instrument from the same manufacturer. Using the largest possible sample area and averaging measurements on several samples from the same batch of material will also help. In all cases realistic tolerances for acceptable color should be set, which will be higher than those of opaque or transparent materials.