Optical Properties, Definitions and Measurements

As the power and utility of LEDs has grown, so has the use of optical-grade silicones. Their versatility and unique physical properties allow silicones to now be used in many new ways such as light pipes, lenses and other secondary optics.

Optical properties are critical to material and design choice, impacting device performance. Unfortunately, not everyone defines the measurements identically. This bulletin is a guide to optical testing terminology, with a description of how optical properties are measured and calculated by Dow Corning, as well as the definitions used in its specifications.

Optical Properties

The three principle effects on light interacting with matter are Reflection (R), Absorption (A) and Transmission (T).
**Definitions**

**Absorption:** Light that is “captured” by and dissipated as heat within a material as it passes through.

**Absorption, calculated \((Ac)\):**
The measured absorption of a material, mathematically corrected for a single pass through a sample correcting for the effect of reflections.

**Absorption coefficient \((\alpha)\):**
The material specific exponential coefficient defining transmission or absorption for a given sample thickness. This quantity is independent of sample thickness, thus two thicknesses of the same material will give the same absorption coefficient \(\alpha\), though different values of absorption \(A\).

**Absorption, measured \((A)\):**
The amount of light absorbed as measured as the difference between the source power and the transmitted and reflected light, including any effects of multiple reflection.

**Albedo:** Proportion of light scattered upon surface reflection (See Reflection, diffuse) to the incident light.

**Haze:** Measure of scattering calculated by the ratio of diffuse transmission and total transmission.

**Diffusion:** Light scattered from surface roughness, or particles, voids and even slight material variations in a sample, may be minimized or set to a known level depending on application needs.

**Nanometer \((nm)\):** A unit length equal to one billionth of a meter \((10^{-9} \text{ m})\) commonly used to measure the wavelength of light.

**Reflection:** The portion of light that ‘bounces’ off a sample surface.

**Reflection, calculated \((Rc)\):**
The measured reflection from a surface, mathematically corrected to remove the many partial reflections that occur within the material itself.

**Reflection, diffuse \((Rdif)\):** Light reflected in many directions from an uneven surface.

**Reflection, direct \((Rdir)\):** Light reflected at an identical angle to the incident beam, often referred to as specular reflection.

**Reflection, measured \((Rt)\):**
The measure of the total light reflected in the direction of the source, including internal and external surfaces.

**Refraction:** The bending of light rays when they pass between materials with different refractive indices.

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**Calculated Reflection**

Light reflects off all surfaces of a material and in many directions (diffuse reflection) as well back towards the source (direct reflection). Measured reflection \((Rt)\) captures most of the source directed reflections, while calculated reflection \((Rc)\) removes secondary reflections.
**Refractive index** ($n$): Material specific index which determines how light is refracted, or bent as it passes into and out of a sample. Refractive index is dependent on the details of the material composition and structure.

**Spectrophotometer**: An instrument used to measure the optical properties of materials across “spectrum” of light energy wavelengths. (250-1700 nm for Dow Corning testing purposes)

**Spectrum**: Originally the range of colors of visible light, but now applied to the entire range of electromagnetic transmission. (250-1700 nm for Dow Corning testing purposes)

**Transmission**: Light which travels through a sample without being absorbed or reflected, but includes light which is scattered forward.

**Transmission, calculated** ($T_c$): Transmission corrected for reflection losses, simplifying the comparison of materials with different refractive indices.

**Transmission, diffuse** ($T_{dif}$): The measure of the amount of light scattered while passing through a material. (See Haze)

**Transmission, direct** ($T_{dir}$): Light passed directly through a sample without scattering.

**Transmission, total** ($T_t$): The sum of all light that passes through a sample.

**Wavelength** ($\lambda$): The smallest distance between two peaks of an electromagnetic (light) wave. Visible wavelengths range from approximately 390 to 750 nm.

**Refraction**: Change in propagation direction as light moves between samples with different indices of refraction.
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