

What is color?

A simple dictionary definition of color is “the effect on the eyes of transmitted or reflected light of different wavelengths.” As such, measurement of color is a more complicated proposition than the measurement of a purely physical attribute such as density or viscosity.

How does color relate to Pilot products?

Color is a very important factor in Pilot products. There is a perception, in very general terms, that color is an indication of the presence of impurities. Hence, the lighter the color, the higher purity of the material in question. Pilot products range in color from nearly colorless (e.g. SLS and low active ether sulfates) through a range of yellows and orange-browns (e.g. LAS derivatives and amides) to dark brown (Aristonates) and even brown-black (some Aristonic Acids).

How is color measured?

Solution methods can be roughly divided into two groups: a) transmittance and absorbance methods; % Transmittance and Klett and b) color comparison methods; the Gardner and APHA (Hazen) scales.

Why are there so many different methods?

Not every color method can cover every range of color density.

a) Transmittance/absorbance methods. These methods generally utilize a spectrophotometer to measure the amount of incident light either absorbed by (A) or transmitted through (%T) a sample solution. Any values measured by one of these methods need to be qualified in three ways.

1. The absorbance of a sample is directly proportional to the amount of the absorbing material through which the light must travel. Both the thickness and concentration of the sample must, therefore, be specified. The sample thickness is usually referred to as the path length. (For Pilot's purposes, the concentration of a sample is specified as a % dilution, a % active or “as is”).
2. Since no material absorbs at exactly the same level throughout the entire spectrum, the wavelength or range of wavelengths of light used for the measurement must be specified.

By practical necessity, these methods can only be used on lighter colored materials (or dilute solutions of darker products).

b) Color comparison methods. These methods utilize a simple visual color comparison. The operator selects from a graduated scale of standard colors a color that is a satisfactory match for the color in question. Color comparisons are effective for a wider range of color densities. The Gardner scale is especially useful for darker materials. Again, as with the A and %T methods above, the sample solution concentration must be specified. For the Gardner scale the path length is automatically specified by the use of standard Gardner sample tubes.

Which methods are used by Pilot?

Color of Pilot's products are quantified by three main methods. All of these methods are designed to give an estimation of color density in the yellow to brown range:

1. **% Transmittance.** %T is used for the few products which are expected to be colorless or very pale yellow, i.e. low active Calfoam SLS and ALS as well as ES and EA ether sulfates. The specification usually calls for a minimum 90% transmittance at 440 nm, a wavelength chosen because that region of the spectrum shows the most variation between different shades of very pale yellow. The measurements are usually made on "as is" solutions using a 1 cm path length.
2. **Klett.** The Klett color determination is another method from group a), covering color densities intermediate between the %T and Gardner groups. Here, the measurement is based on the average light absorption of a solution over a range of wavelengths using a Klett-Summerson photoelectric colorimeter. This instrument allows different wavelength ranges to be investigated by the use of different filters. The filter number used for a measurement must, therefore be specified. (For Pilot's purposes, filter #42 is always used - this filter allows through wavelengths in the 430 - 460 nm range).
The Klett method is that most widely used by Pilot, encompassing measurements on all linear and branched alkyl sulfonic acids (LAS and BAS) and derivatives as well as the Calfax series. Also using the Klett scale are the SXS, AOS, and TLS products, Calsuds 81 and the 60% active ether sulfates. Most measurements are run on either 5 wt.% (e.g. flake products) or 5% active solutions (e.g. AOS-40). Acids are neutralized using triethanolamine (TEA) prior to measurement.
3. **Gardner.** The Gardner (or G) scale is a comparative method best used for more highly colored materials such as Aristonates, alkylates and amides, as well as the CalBlend group and Calimulse PRS. The values range from very pale yellow (1G) to dark brown (18G), however, the scale is insensitive at low color densities when compared to %T or the Klett scale. Aristonates are usually diluted to 10% by weight in toluene prior to measurement, other are measured "as is."

What other methods are used in our industry?

One common method found is the American Public Health Association's platinum-cobalt scale for designating the colors of waters - the so-called APHA system. This scale is basically a gradation of yellow intensity in solutions of varying

concentrations of potassium chloroplatinate and cobaltous chloride. Because of the narrow range of color variations in the APHA scale, it is of limited use, however it is very popular in the cosmetics industry.

How do the different scales relate to each other?

Number correlation between scales is not easy, since the APHA and Gardner scales are comparative, while the Klett and %T methods give actual values. The color comparator on the next page is based on work done at Pilot over the last few years. All work was done using standard APHA solutions. The Klett readings were obtained on the APHA solutions using the #42 filter and a 40 mm path length (Klett approximates 0.6 x APHA up to ~200 Klett). The %T numbers were obtained from these same solutions at 440 nm and a 10 mm path length (under these conditions, 90%T approximates 100 Klett and 160 APHA). The Gardner scale is included, but the values should be only taken as a very rough guide.

