Application Note

AN 1004.01

Measuring Degrees of Yellowness with Gardner Index

"Visual color scales, including the Gardner Scale, have two inherent flaws – one is the variation in the color of standards, batch to batch. The second and most obvious is the variability of the human observer."

ABSTRACT

The Gardner Scale is a visual scale originally developed in the 1920s to describe the color of drying oils, varnishes, fatty acids, polymerized fatty acids and resin solutions. These liquids are generally a moderately-saturated greenish or reddish-yellow color in the raw form, and get progressively clearer at higher levels of processing. As the science of color measurement has developed, the Gardner Scale has been correlated with colorimetric scales.

This application note considers the original visual scale and its relationship to instrumental methods ASTM D1544 and D6166.

The world's true measure of color

HunterLab

CHALLENGE: To relate visual Gardner color scale to a colorimetric method with an Instrument.

The original Gardner visual scale describes a degradation of near white or clear products due to age, exposure to light/chemicals and processing. The Gardner scale contains a set of 18 visual transparent standards made of potassium dichromate, ferric chloride, cobaltous chloride, and potassium chloroplatinate to set levels of yellowness. These solutions although sealed in glass, were unstable, faded with time and difficult to reproduce. These chemical solutions were eventually replaced with glass filters on a wheel (See Figure 1).

As the standards range from 1 to 18, the color goes from light to dark, increasing in dominant yellow saturation, and shifting from a greenish tint to a red tint.
With the advent of instrumentation, the visual scales were correlated with colorimetric scales. The first of these colorimetric scales provides a relationship between Garder Index and CIE Yxy (ASTM D1544). The second published method of comparison triangulates the relationship to chromaticity values (ASTM D6166).

The Gardner Scale was developed separately from other Yellowness indices such as ASTM E313, ASTM D1925 and APHA.

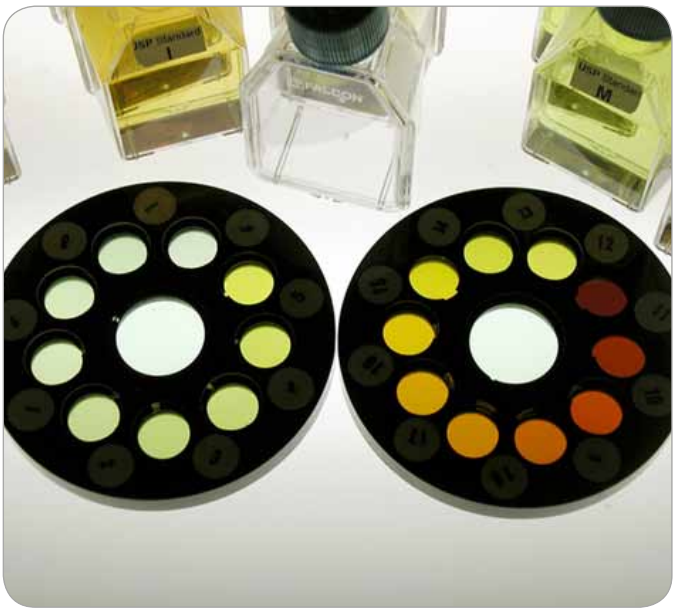


Figure 1. Gardner Index Glass Filters.

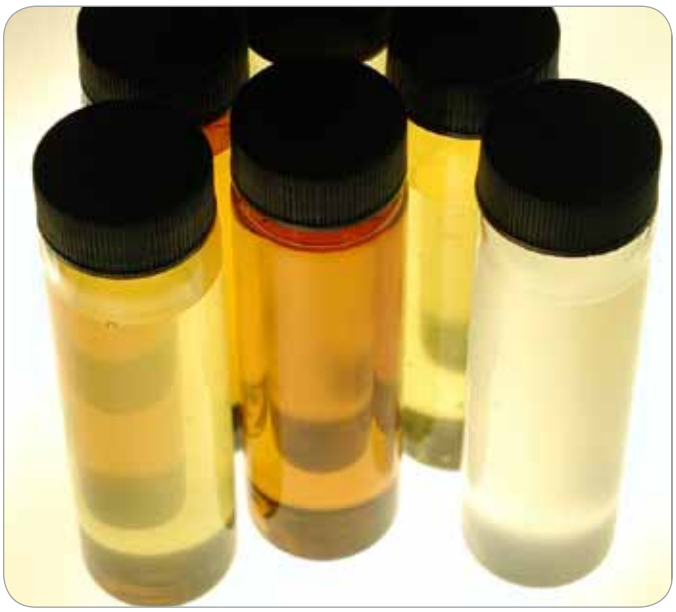


Figure 2. Liquid Resin Samples representing the types of samples easily described by Gardner Index.

GARDNER SCALE VS. ASTM D1544 (STANDARD TEST METHOD FOR COLOR OF TRANSPARENT LIQUIDS)

To relate the visual Gardner standards to a colorimetric measurement, the eighteen visual Gardner standards are compared to CIE Chromaticity Coordinates (Table 1) in a lookup table. Measurements are made on any colorimeter or spectrophotometer and read in transmittance using a 20 mm cell. The results are shown in Table 1 on the following page.

TABLE 1.			
ASTM D1544	**CIE Chromaticity Coordinates (C / 2°)**		
Gardner Color	**Y**	**x**	**y**
1	80	0.3177	0.3303
2	79	0.3233	0.3352
3	76	0.3329	0.3452
4	75	0.3437	0.3644
5	74	0.3558	0.3840
6	71	0.3767	0.4061
7	67	0.4044	0.4352
8	64	0.4207	0.4498
9	61	0.4343	0.4640
10	57	0.4503	0.4760
11	45	0.4842	0.4818
12	36	0.5077	0.4638
13	30	0.5392	0.4458
14	22	0.5646	0.4270
15	16	0.5857	0.4089
16	11	0.6047	0.3921
17	6	0.6290	0.3701
18	4	0.6477	0.3521

GARDNER INDEX VS. ASTM D6166

In June 1997, the ASTM D01.34 (Naval Stores) subcommittee approved another instrumental correlation to the visual Gardner Color Scale. This new instrumental Gardner scale is based on a 10 mm path length transmission measurement and is described in ASTM D6166, Standard Test Method for Color of Naval Stores and Related Products (Instrumental Determination of Gardner Color). This color scale triangulates the chromaticity coordinates and expands the values to include a decimal. This scale is thought to be more robust for off-hue samples.

Both of these scales are widely used today and are implemented in the EasyMatch QC software packages.

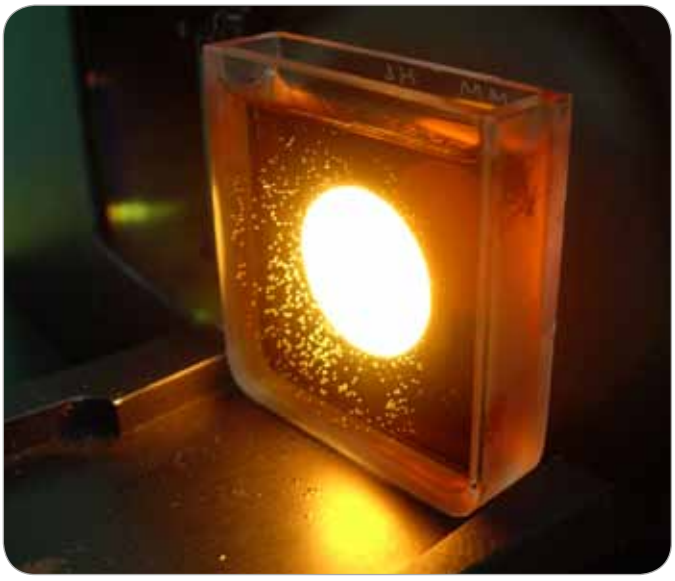
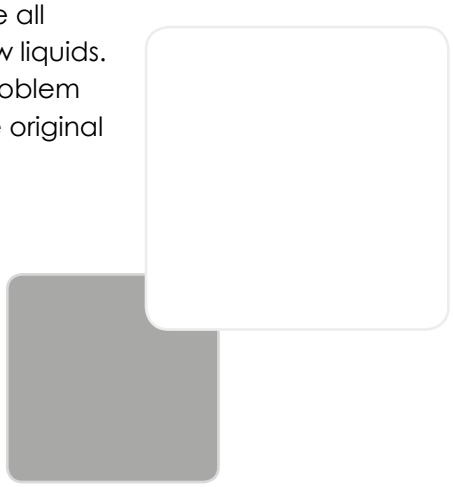


Figure 3. 10 mm Transmission Cell with typical liquid sample measured for Gardner Index.

SUMMARY

The Gardner D1544 using Chromaticity Coordinates, and D6166 indices are all effective for instrumentally measuring the Gardner Color of chromatic yellow liquids. These methods remove the subjectivity of visual measurements and the problem with reproducibility of making visual standards but still strongly relate to the original visual color scale.



REFERENCES

Huebner, Fred E. and Harry N. Monck, "Measurement of Color in Resins and Adhesive Systems"Journal, September 1992.

ASTM D6166, Standard Test Method for Color of Naval Stores and Related Products.

ASTM D1544, Standard Test Method for Color of Transparent Liquids.

More Information about Color Measurement on our HunterLab Blog

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ABOUT HUNTERLAB

HunterLab, the first name in color measurement, provides ruggedly dependable, consistently accurate, and cost effective color measurement solutions. With over 6 decades of experience in more than 65 countries, HunterLab applies leading edge technology to measure and communicate color simply and effectively. The company offers both diffuse/8° and a complete line of true 45°/0° optical geometry instruments in portable, bench-top and production in-line configurations. HunterLab, the world's true measure of color.

Hunter Associates Laboratory Inc.,
11491 Sunset Hills Road, Reston, VA 20190-5280 USA
support@hunterlab.com
www.hunterlab.com

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