Microfade Testing to Predict Change

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The microfading tester (MFT) provides a means to measure the potential impact of light on cultural objects by illuminating a minute area of an object and measuring the changes in color that result in real time with a spectrophotometer (fig. 1). It is particularly useful for objects known to be susceptible to damage by light exposure, such as works on paper, textiles, and photographs, especially those with unknown exhibition histories. Improperly processed photographs can change extremely rapidly while on display. It should be noted that "color change" is a more accurate description than "fading" for what the microfading tester measures because exposure to light does not always result in the fading, or lightening of colors; it can also induce darkening and color shifts.

Microfade testing offers a predictive alternative to direct monitoring, a method that has been widely used the museums since the 1980s to measure changes to objects that occur over time.[1] Unlike microfade testing, which is performed in advance of exhibition to prevent the possibility of light-induced damage due to display, monitoring requires that a densitometer or colorimeter be used periodically over the course of an exhibition. This method subjects the object to repeated exposure to light with a much larger aperture than the MFT. The repeated exposure to the intense light of the measuring instrument might itself result in fading or color change. Furthermore, it is possible that the irreversible light-induced damage revealed after the fact by monitoring might have been prevented had the object been tested beforehand with the MFT.

The idea for constructing an instrument to test for rapid fading in a small area was discussed in the early 1990s,[2] but the MFT was independently developed and constructed by Paul Whitmore later in the decade.[3] It consists of a high-intensity xenon arc lamp filtered to exclude both ultraviolet (below 400 nm) and infrared (above 700 nm) radiation to mimic the light falling on objects in a typical gallery setting. The illumination from the lamp is directed through a single fiber optic perpendicularly (0°) to the surface being faded and focused to a very small spot, typically 0.3–0.5 mm diameter, by a set of lenses. The result is an incident illumination of approximately 5 Mlux.[4] The reflected light is collected at 45° to the surface by another fiber optic lens assembly focused on the illumination spot and directed to a spectrophotometer that records the spectrum (fig. 2). The reflectance spectra are collected approximately once every second, and each is compared to the spectrum at the start of the measurement. The difference between any spectrum and the spectrum at time zero is calculated in real time using the CIE 1976 color-difference equation resulting in the value, ΔE_{76}.[5] In theory, a ΔE_{76} value of 1 corresponds to a just-perceptible change in color. Since the change can be measured in real time, the illumination can be stopped if the ΔE_{76} value becomes too high. Various researchers have reported that ΔE_{76} values greater than 2 can be seen only in perfectly homogeneous fields of color and that typically ΔE_{76} values of up to 5 cannot be seen. In addition, the small size of the illumination spot makes it difficult to see even if the color has noticeably changed.

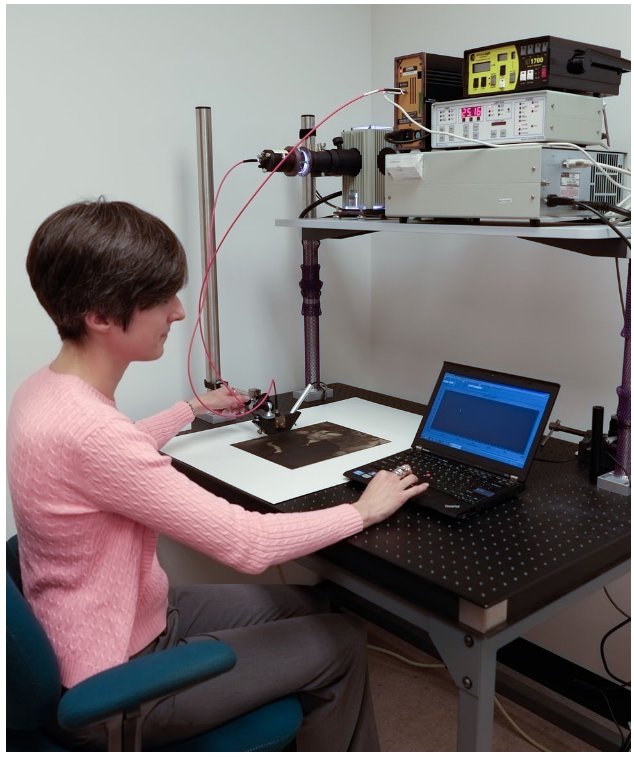

Figure 1. Conservation scientist Joan M. Walker operating the microfading tester at the National Gallery of Art. The tester was assembled in 2004 from Newport-Oriel components described in Whitmore et al. 1999 and used on a movable Thorlabs bench.

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Figure 2. Microfading tester measurement head, designed by the author in 2006. The head is held at approximately 1 cm from the surface being tested. Focused light from the illumination fiber optic can be seen at the edge of this gum dichromate over platinum print by Heinrich Kühn (fig. 20 in Andreas Gruber, "The Platinum Print Technology of the Austrian Pictorialist Heinrich Kühn," in this volume). The collection fiber optic (red) and the digital endoscope (silver), which is used for accurately positioning the measurement head, are both at 45° to the illumination fiber optic.

Various modifications have been made to the initial Whitmore design, mostly involving the light source and/or the illumination-collection optic assembly (measurement head) to make the overall instrument smaller, improve efficiency, and frequently to improve precise positioning of the measurement head.[6] The initial Whitmore measurement head does not touch the surface being measured, but some of the later designs incorporate a contact measurement head.

Notes

1. Wilhelm 1981.
2. Bergeron and Costain 1992; Ware 1994, 61–63.
3. Whitmore et al. 1999.
4. Druzik and Pesme 2010.
5. ISO 11664-4:2008 (CIE S 014-4/E:2007) Colorimetry—Part 4: CIE 1976 L*a*b* Colour Space, www.iso.org.
6. Lerwill et al. 2008; Liang et al. 2011; Whitmore and Tao 2011; Pesme et al. 2016.

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