The role of variable measurement angles and smooth and textured surface states in retro-reflective microfading tests

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Introduction

Light is an important ‘agent of change’[1] for heritage collections as it can cause irreversible change such as discolouration or loss of material strength. Heritage institutions aim to control light-induced degradation by classifying collection items into light-sensitivity categories and limit exhibition lighting accordingly [2, 3].

Microfading allows to directly measure the light sensitivity of an object quickly – within minutes – without the need to analyse its composition. These are distinct advantages over other assessment methods such as colorimetric monitoring before and after exhibitions or accelerated degradation tests in light chambers on surrogate materials.

A microfading tester (MFT) exposes a small area of an object – diameter approx. 0.2 to 1.0 mm – to light of high intensity between 2 and 20 Mux (Fig. 1). The change of reflectance is measured simultaneously by a spectrophotometer. The reflectance data is conventionally converted into colour change ΔE, which can be related to perceptible change. ISO Blue Wool standards (BWS) are used as the reference scale, hence, light sensitivity is expressed in Blue Wool Equivalents.

The test is virtually non-destructive due to the scale of the sample spot and the fact that the colour change in the sample area is usually not perceptible. Microfading is used to assess diverse materials such as fine art and graphic media, textiles, photographs etc. However, there are inherent uncertainties and challenges, e.g. the non-standard instrument design and the impact of surface and optical properties such as texture, gloss or translucency.

Method

The aim of this project is to investigate the impact of the test angle, i.e. the angle of incident light, in relation to smooth and textured surfaces. The research questions are:

- Is it necessary to calibrate the instrument at the measurement angle?
- Does the angle of measurement impact the data?
- How does textile texture impact the data?
- What are the implications for practical microfading tests on smooth and textured materials?

Research questions

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Test angles: 15˚, 30˚, 45˚, and 60˚.

Light: 4-channel LED Lamp.

Temperature in sample spot: approx. 26°C

Colorimetry: Standard illuminant D65; 2° Standard Observer CIE L′Wr°3; CIE 2000 colour difference equation.

Parameters measured: reflectance R [%] and ΔE00

Focusing: an unprinted white material at approx. the same height as the sample.

Test parameters: Table 1

Table 1 Test parameters.

Results

- The instrument should always be calibrated at the test angle. If the calibration is not done at the test angle, the decrease in spatial power distribution of the light spot at larger angles (Fig. 3) will result in a decrease of the reflectance of approx. 50 % at 60˚.
- Smooth, plane and opaque full tone materials:
  - There is a degree of flexibility regarding the calibration and test angle at 15˚ – 30˚.
  - When the instrument is calibrated at the test angle, reliable fading data can be obtained at angles 15˚ – 45˚.
- A test angle of 60˚ results in underestimation of the fading rate.
- Materials with directional texture similar to the sample material:
  - Reflectance and fading data are significantly influenced by the test angle and sample orientation. The difference in the fading rate can cover one BWS step.
  - Test angles of 15˚ – 30˚ are likely to give realistic data, whereas tests at 45˚ – 60˚ probably underestimate the fading rate. It is recommended to carry out a series of tests at 15˚ or 30˚ with random sample orientation to avoid the impact of surface effects.
  - A conservative approach to the categorization into BWS classes is recommended to avoid misclassification due to surface effects.

Future research

- Assessment of the effect of different focusing techniques on textured materials.
- Investigation of the impact of reduced flux density at larger test angles for light tone materials that are smooth, plane and opaque.
- Modelling of surface topography in relation to the incident light beam to better understand the impact of back-scattered reflection in textured materials.
- Investigation of the impact of directional texture of different scales on microfading data to formulate a test protocol for textured materials.

References


Fig. 1 Microfading of a drawing: Metis ISO Blue Wool Equivalents.

Fig. 2 The cotton twill fabric.

Fig. 3 Evolution of the spatial power distribution in the illumination spot at increasing test angles.

Fig. 4 Fading rates AE00/10min of the test fabric in two different sample orientations and at varying test angles.

Fig. xxx Surface image of a pellet (x100).

Fig. xxx – Fig. xxx: T...