Microfading Tester Evaluates Colorant Fading Behavior

Instrument Design
The microfading tester is a custom-built instrument using three basic components to measure color under high-intensity illumination: a light source (currently we are using an Apex portable xenon arc lamp from Newport Corp., with filters to eliminate UV and IR radiation); optics to deliver and focus the light onto and to collect reflected light from a very small area on an object surface; and a photodiode array spectrophotometer.

Practical Use
These tests can identify at-risk colors on objects, paintings, prints – essentially any colored material – and the information can inform how an object might be protected in future exhibition conditions.

Capacities
The instrument delivers a light dose equivalent to a few years of gallery exposure during the test, which takes minutes to perform. Materials whose colors are sensitive to light will react during the test. Because the microfading test is essentially nondestructive (leaving no trace of altered color where the test is performed), presentation surfaces of objects can be quickly screened for their lightfastness in future exhibition conditions.

Sample results for a microfading test. Color changes ($\Delta E$) induced by light exposure of areas on object are compared to response of ISO standards for lightfastness (Blue Wool 5, or BW, #1, 2 and 3). BW 1 is the most light sensitive and BW 3 is the slowest to fade of the three standards. Results like these show the likely impact of exhibition.

Spot fading to $\Delta E = 5$, the maximum change in color allowed during a test, is not visible even when magnified. (image credit: Paul Whitmore)

AFM images at top (size: 3 $\mu \text{m} \times 3 \mu \text{m}$) of (a) the polyethyleneimine (PEI)-treated glass coverslip, (b) Ag nanoparticle assembled film on the glass, and (c) Ag,N nanoparticle assembled film obtained from the gas–solid reaction. The Z range units are on the nanometer (nm) scale. TEM images at bottom of (d) PEI nanosize domains, (e) Ag NP assembly, and (f) Ag,Sn nanoparticle assembly obtained from the gas–solid reaction (all deposited on formvar/carbon film copper grids). (from Chen et al. 2008)

The decreasing absorption intensity of the Ag NP films with reaction time at different gas concentrations. A% is the percentage of remaining absorbance of the Ag NP films (related to the amount of unreacted Ag on the surfaces of the nanoparticles). (from Chen et al. 2013)

Selected Publications

Silver Nanoparticle Films as Gas Sensors

Detecting Unsafe Storage Environments
The Yale University Art Gallery’s Wurtele Collection Study Center is a uniquely accessible storage space that provides unparalleled access to the Gallery’s collections for hands-on scholarship. The new ventilation system was designed to provide pure, low humidity air for the silver objects stored in the cases. A worrying odor started to emanate from the cases, and silver nanoparticle film sensors uncovered a serious air quality problem, traced to a malfunctioning water purifier in the humidification system. In this instance, the silver nanoparticles sensed the risk before the YUAG silver collection was moved into the cases, where the objects would have signaled the air quality problem by becoming tarnished.

Nanoparticles for Traditional Material Compatibility Testing
The Oddy test was created at the British Museum in 1973 as a standardized way of determining whether a material intended to be in contact or in a closed environment with art objects was compatible with the art material. The Oddy test uses copper, lead, and silver coupons as proxies for art materials, and involves enclosing the proposed material with these coupons in a hot and humid environment for 28 days. The enhanced reactivity of nanoparticles is a welcome alternative that promises to speed the tests and allow quantitation of the results.

Selected Publications
• R. Chen et al., “Silver sulfide nanoparticle assembly obtained by reacting an assembled silver nanoparticle template with hydrogen sulfide gas.” Nanotechnology 2008, 19, 455604.