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A Lacquer to Dye For! Exploring a UV-fluorescent additive for coating application in silver conservation

COATING SILVER AT WINTERTHUR

Winterthur's Conservation and Scientific Analysis Departments developed a robust silver coating program over 40+ years. The last phase of collaborative research was 2016-2019. Building on practices from colleagues at the Museum of Fine Arts Houston and Colonial Williamsburg, we refined our Agateen® Lacquer #27 recipe by adding UV-fluorescent dye Coumarin-6.

Why Coumarin-6?

- Not detectable in visible light once applied to silver but fluoresces yellow-green in long-wave UV
- Enables conservators to immediately assess their coating application

We wanted to understand the long-term effects of this additive.

USING COUMARIN-6

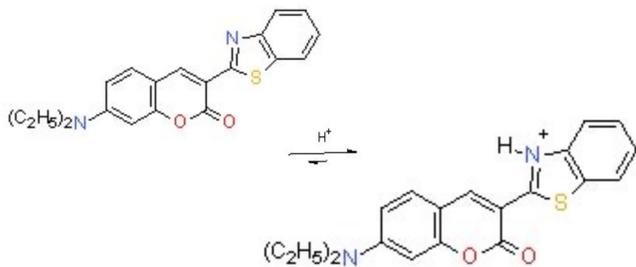
This recipe minimizes detection in visible light but produces useful fluorescence in UV light:

1. Make stock 0.025% C6 stock solution: dissolve 0.025 g C6 in 100 mL Agateen Thinner #1
2. For brush application, 200 mL lacquer: 200 mL thinner: 2 mL C6 stock solution
3. For spray application, 135 mL lacquer: 270 mL thinner: 1.5 mL C6 stock solution

Store in a well-sealed container in a dark cabinet, and thoroughly clean workspace—dye is highly concentrated and contaminates spaces easily.

FLUORESCENCE MECHANISM

Coumarin-6, a well-known fluorescent probe in the medical field, has been thoroughly studied for its properties in various media. The dye has an excitation peak around 420 nm, and a fluorescence peak around 520 nm. However, the dye is known to quench when it becomes deprotonated in acidic environments (Mina 2013). The observed yellowing of the coating after 12 months correlates with the observed quenching of the dye.



PROTONATED AND DEPROTONATED COUMARIN-6



AFTER TREATMENT (UV)



AFTER 12 MONTHS IN AMBIENT CONDITIONS (UV)



AFTER 12 MONTHS IN AMBIENT CONDITIONS (VIS)

Fluorescence images of a coated silver tray (1983.0108.001) were captured after coating (top) and again after one year in ambient conditions (middle); visible light image captured after 12+ months (bottom). UV images captured with Nikon D850 camera with 20-mm lens, Peca 918 filter, UV filter (similar to Kodak Wratten 2E gel filter), 30-second integration time, and 365-nm UV light source

REFERENCES

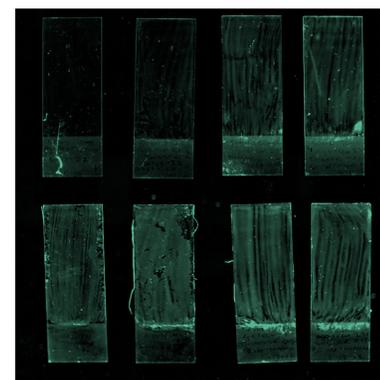
Mina, M. V., I. P. Puzyk, and M. V. Puzyk. "The effect of acids on fluorescence of coumarin-6 in organic solvents." *Optics and Spectroscopy* 114, no. 2 (2013): 244-246.

DYE PROPERTIES OVER TIME

UV images clearly show that the fluorescence wanes after ambient exposure (full spectrum visible light). The rectangular shape of brighter fluorescence in the center of the tray (middle image) directly corresponds to a paper "move form" sitting atop the object during the 12 months and protecting that area from direct light exposure.

Also of note is a clear shift in the visible spectrum: the coating appears more yellow in select areas of the tray after one year of ambient exposure (bottom image).

Fluorescence measurements collected from unaged and thermally aged films containing a range of dye concentrations showed that fluorescence increased *without* exposure to UV, even in the undyed coating.



UNAGED

AGED AT 80 °C, 80% RH for 400 hours

From left to right: 0%, 0.025%, 0.05% and 0.1% C6 stock solution before aging (top) and after aging (bottom)

DOES COATING DEGRADATION CAUSE DYE QUENCHING?

FT-IR data was collected from clear and colored films, without the presence of dye. This data suggests that there is **no direct correlation** between nitrocellulose degradation, nitration level, and film color.

Next steps to answer this question will employ gel permeation chromatography to observe MW distribution of UV-degraded cellulose nitrate with and without the Coumarin-6 dye.

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Image credit: Aaron Morris and Jim Schneck

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