Diffuse Reflectance Targets for UV-Visible Fluorescence

Diffuse reflectance targets are used in scientific analysis to calibrate instruments and detect background noise. In ultraviolet induced visible fluorescence (UVF) imaging applications, these targets provide valuable information about radiation sources and light leakage.

Diffuse Reflectance Targets

Diffuse reflectance targets reflect 95-99% of wavelengths across the UV-visible-infrared (IR) range (250-2500nm). The wavelengths are reflected in a "diffuse" manner, meaning that the apparent brightness is the same regardless of the angle of reflectance. In short, the surface is matte. Brand names of targets available include, Spectralon, Zenith Lite™ , and Permaflect®. Many of the formulations are patented, with the main differences being the composition and finishing of the target, including its resistance to scratching, water, and dirt accumulation. Numerous targets are made from polytetrafluoroethylene, (PTFE, common brand name, Teflon).

Overview of UVF Imaging

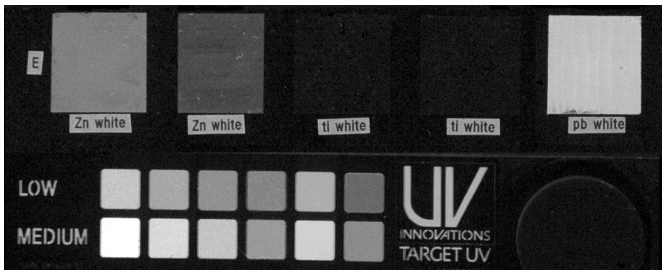
UVF is an important non-destructive technique for cultural heritage because it provides information about the constituents and condition of a wide range of materials. In this technique, the object is exposed to UV radiation (typically UVA) in a darkened room. With some materials, the radiation is absorbed, then re-emitted at a higher wavelength, a phenomenon known as fluorescence. When the emitted wavelength is in the visual spectrum, it can be perceived by the human eye and captured using a conventional film or digital camera as visible fluorescence.

Many pigments, resins, adhesives, and dyes used in the creation of art have known fluorescence behavior. For example, natural resin varnishes will often produce a light green fluorescence, while synthetic varnishes typically exhibit no fluorescence. White pigments such as zinc white, titanium white, and lead white have unique fluorescence characteristics that can often help differentiate them. For conclusive identification of materials, this technique should be complemented with scientific analysis because many factors can influence the fluorescence, including aging, thickness, and processing.

The Problem of Light Leakage in UVF Imaging

Visible light leakage can inhibit our ability to perceive small differences in fluorescence. It acts like a filter or color cast on the surface that may confuse the viewer, disrupt color perception, and sometimes be confused for fluorescence itself. There are two main sources of light leakage in UVF imaging. First, incomplete darkening of the documentation area allows natural light or light from surrounding rooms to leak into the image. The second, more insidious source, is the UVA lamp itself. Leakage from the lamp will appear as blue or violet light. This leakage is so ubiquitous that people often *expect* to see the blue cast as an indicator of UV visible fluorescence. UV radiation is invisible to the human eye, so any light visible when the lamp is turned on is indicative of leakage. The main tool for limiting visible light leakage from the lamp is filtration. UV-pass filters installed over the lamp limit visible light by absorbing or blocking emission beyond 400nm. Common filters for UV lamps are Wratten 18a (Wood's filter) and Schott UG-1 or UG-11. UV-pass filters on the lamp are used in conjunction with a UV-cut filter on the camera, which will reduce the impact of leakage on the image. The most common on-camera filter for UVF imaging is the Wratten 2e, which cuts below 420nm. Visible light leakage will be most noticeable in images of materials with weak fluorescence that need long exposure times.

UVF image of white pigments captured with minimal visible light leakage, note that the diffuse reflectance target is not visible, nor are the samples of titanium white.



UVF image of white pigments captured with visible light leakage, note that the diffuse reflectance target is visible and shows a similar appearance to the titanium white samples.

Use of Diffuse Reflectance Targets in UVF Imaging

Diffuse reflectance targets provide a visual indication of visible light leakage, communicating vital information to viewers about image quality and color casts that may not be due to fluorescence. The target reflects 95-99% of the UV-visible-IR radiation that is present in the room. In UVF imaging, only visible light is captured by the camera, UV and IR wavelengths are filtered out of the image. Thus, the image of the target will only reflect leakage in the visible range. In an ideal UVF imaging environment, with no visible light leakage, this target will appear black.

In a non-ideal environment, the target will reflect the color of the leakage, so blue or violet appearance indicates leakage from the lamp or another source producing that color. White or other colors may indicate incomplete darkening of the room or less conspicuous sources (look for "EXIT" signs, optically brightened materials in the imaging area, fluorescence from clothing, or indicator lights on your equipment). The target can also pick up reflectance from the object itself, particularly if the fluorescence is very bright or during long exposures.

Diffuse reflectance target	Pros	Cons
Branded target (Spectralon, Zenith Lite, Permaflect)	robust housing / cover scratch resistant water resistant sometimes polishable	cost > $375
PTFE (Teflon)	readily available low cost doesn't attract dust	scratches easily does not adhere to suraces well surface sheen can pick up reflections
Titanium white in an acrylic binder	readily available low cost easy to apply to existing targets	scratches easily attracts dust not resistant to handling difficult to clean

Choosing a Diffuse Reflectance Target

Because of their nature as calibration tools for sensitive instrumentation, true diffuse reflectance targets are highly engineered and expensive. Though not precise enough for calibration of instruments, there are numerous low cost and DIY options that can provide the benefits of diffuse reflectance targets in UVF imaging.

White PTFE is the most obvious choice for a low-cost target because numerous branded targets are made from this polymer. PTFE is available in sheets of varying thicknesses from suppliers such as Amazon and Grainger. Thicker sheets (> 1/8 inch) are preferable because they prevent show-through from the background. Conservation labs may already have PTFE spatulas or "bone" folders, which can be used for imaging (if clean). PTFE will scratch easily. Without surface treatment, PTFE may have a shiny surface, meaning it is not truly "diffuse," but this is not usually a problem for imaging.

Another low-cost option is a thin film of titanium white pigment. Pure titanium white exhibits no UV visible fluorescence, but the white nature of the pigment will reflect visible light reliably. The paint can be applied directly to an existing target, or any non-fluorescent substrate like polymethylmethacrylate (PMMA) or black polyethylene. Acrylic binders tend to be more robust, but watercolor media can be substituted. These films tend to scratch, soil, and flake easily and may need to be replaced or repainted at regular intervals.

The branded and expensive targets offer numerous benefits such as robust housings and increased resistance to scratching, handling, dust, and water. Additional benefits, such as traceable emission and thermal stability are less important for our use.

Diffuse reflectance targets offer a simple and often low-cost way to provide a visual indication of visible light leakage from the imaging environment and equipment. These targets can easily be used with or integrated into existing targets for UVF imaging.

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