# REFLECTIVITY CHARACTERIZATION OF VARIOUS BLACK AND WHITE MATERIALS


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ASTRONOMY

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## ABSTRACT


We report on an expanded catalog[1,2,3,4] of various common (and uncommon) black and white materials used in the construction and/or baffling of optical systems and as screen material for calibration systems. Total reflectance is measured over a broad wavelength range (250 < λ < 2500 nm) that is applicable to ultraviolet, visible, and near-infrared instrumentation. Reflectivity data for the complete sample inventory will be available via Filtergraph, an online data visualization tool.

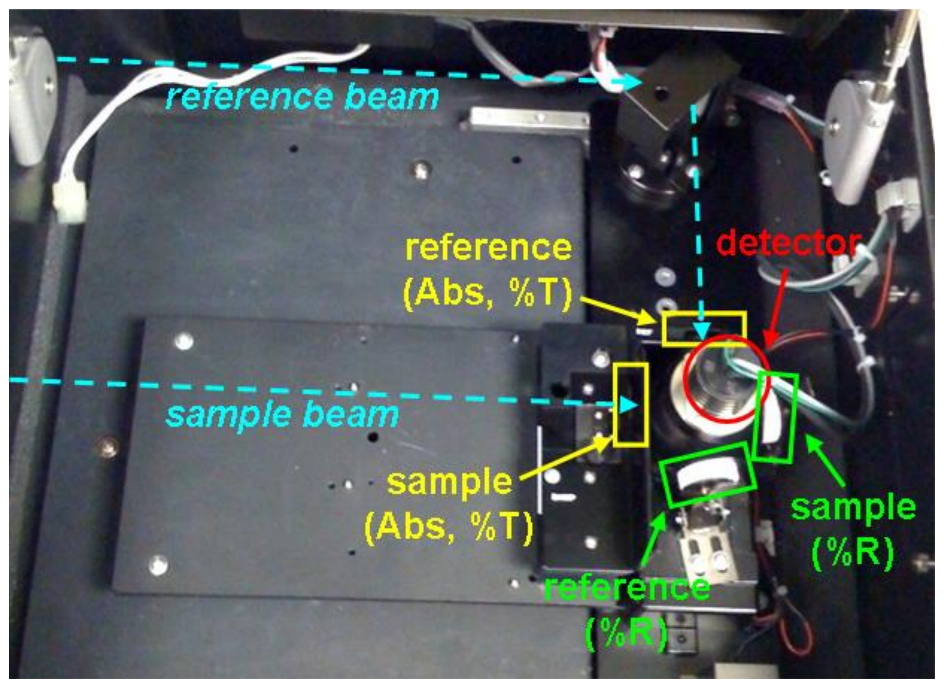
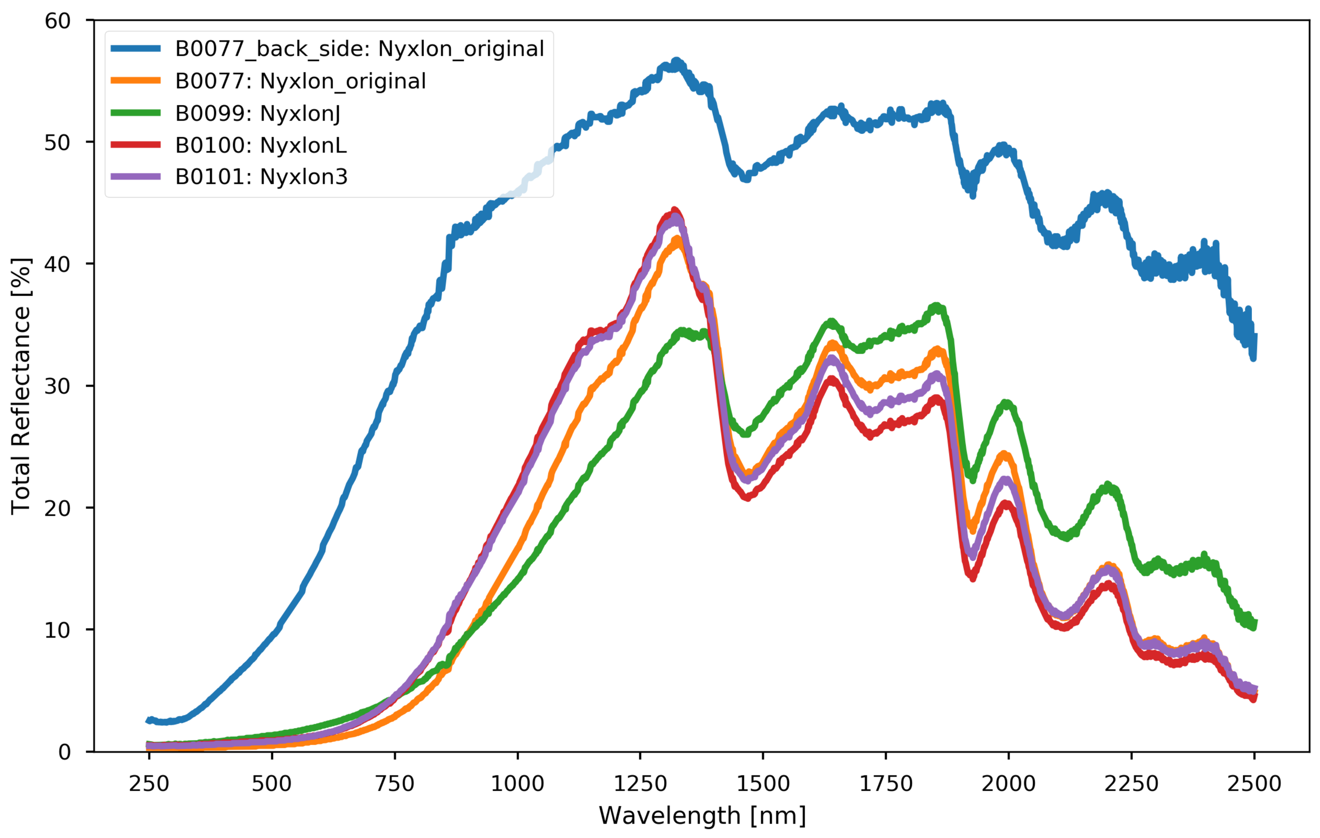




Figure 1. Internal view of the U-4100 UV-Visible-NIR Spectrophotometer. Test samples are placed at the 3 o'clock position (sample %R)

## TOTAL REFLECTANCE MEASUREMENTS

As previously described[4], Texas A&M University maintains a Materials Characterization Facility (MCF) that includes a wide range of instrumentation for investigating material properties. We used the Hitachi High-Tech U-4100 UV-Visible-NIR Spectrophotometer and obtained reflectance profiles for the samples. With this system we measured precise reflectance values at each wavelength (in 1 or 2 nm steps) for the wavelength range 250 nm < λ < 2500 nm. Figure 1 shows the instrumental setup of the spectrophotometer. The reference and test sample are placed in the 6 o'clock and 3 o'clock positions of the integrating sphere, respectively. The data acquisition procedure involves obtaining a baseline measurement at each wavelength of the reference $BaSO_4$ wafers (~100% reflectance) in both the reference and sample slots of the dual beam spectrophotometer. We then measure a second reference sample having 5% reflectivity (Labsphere SRS-05) and measure the reflectivity of the test sample. We compare the 5% reflectance reference sample to the values provided by the manufacturer and use this ratio to construct the absolute reflectivity of the test sample as a function of wavelength. During each day of testing the SRS-05 standard is measured to ensure measurements from different test days are tied to a common reference. The U-4100 changes detectors at 850 nm, which is likely the cause of the features visible in most material scans near this wavelength.

Figure 2. Additional measurements of variations of a wood blackening treatment[4]. The untreated sample is shown in blue, with reflectivity shown for several variations on the treatment process.



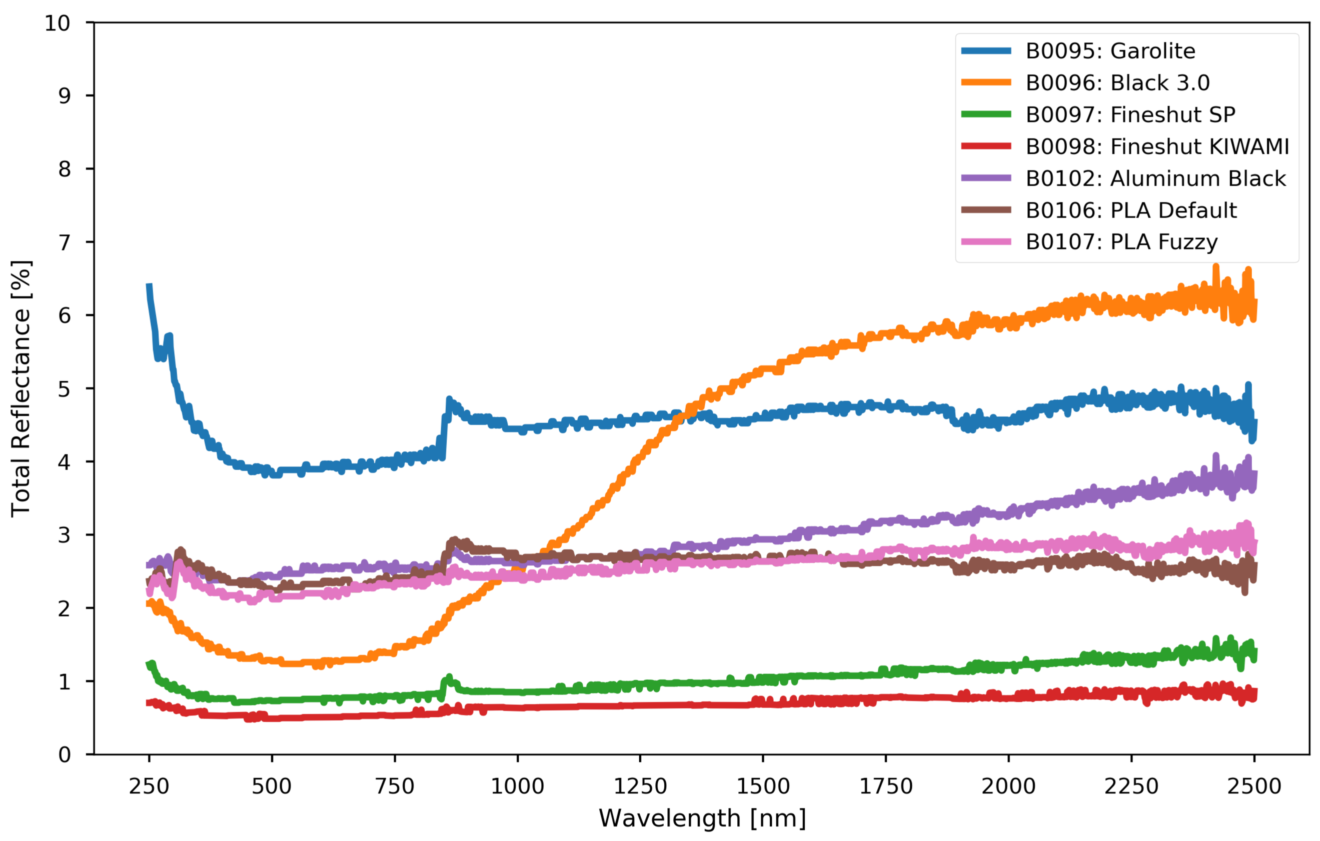




Figure 3. Several new materials were tested. Of particular note, the two Fineshut materials show excellent performance from the UV to NIR and are adhesive backed and very easy to apply either directly, or via submersion in soapy water to allow repositioning. The Fineshut materials can be laser cut to allow for coverage of complex parts. The Aluminum Black treatment for bare aluminum is effective, but difficult to get an even finish. The Aluminum must be freshly machined or cleaned with a Scotch Brite type pad immediately prior to application. PLA 'Fuzzy' print settings add small random motions to the 3D printer print head to generate a textured surface.

| Code | Sample |
|---|---|
| B0077 | Nyxlon (wood surface treatment) |
| B0077 | Nyxlon (wood surface treatment) – Back Side |
| B0095 | Flame-Retardant Garolite G-10/FR4 Sheet |
| B0096 | Black 3.0 Paint |
| B0097 | Fineshut SP – adhesive backed urethane foam |
| B0098 | Fineshut KIWAMI – adhesive backed urethane foam |
| B0099 | Nyxlon J |
| B0100 | Nyxlon L |
| B0101 | Nyxlon 3 |
| B0102 | Birchwood Casey Aluminum Black |
| B0106 | PLA Default Print Settings |
| B0107 | PLA "Fuzzy" Print Settings |

Table 1. List of materials.

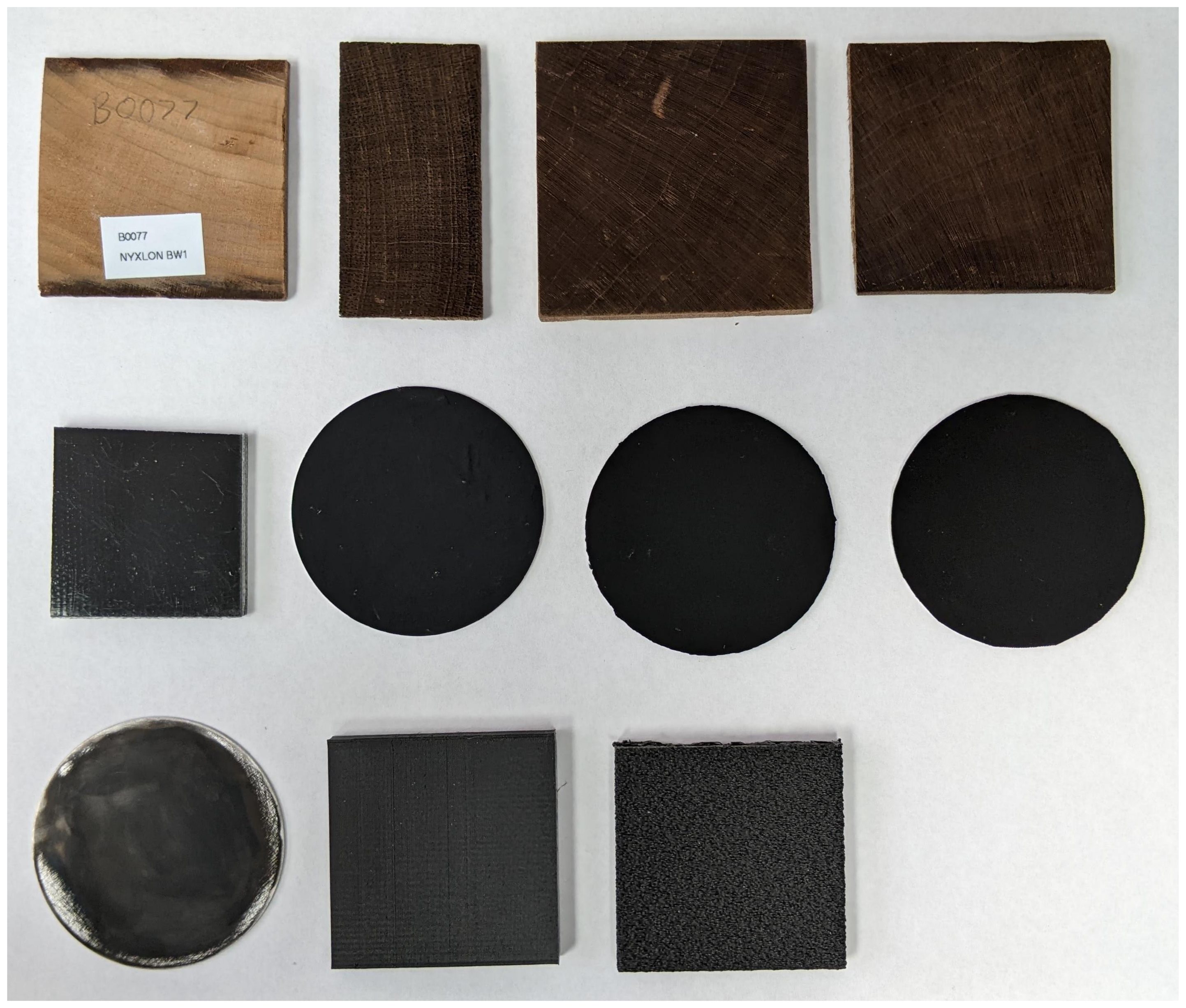


Figure 4. (Row 1, L to R) B0077 Nyxlon back side (to show original color), B0099 Nyxlon J, B0100 Nyxlon L, B0101 Nyxlon 3. (Row 2, L to R) B0095 Garolite G-10/FR4, B0096 Black 3.0, B0097 Fineshut SP, B0098 Fineshut KIWAMI (Row 3, L to R) B0102 Birchwood Casey Aluminum Black, B0106 Black PLA Default print, B0107 Black PLA "Fuzzy" print.

## FILTERGRAPH

Filtergraph[5] is an interactive web based portal for visualization of datasets. To facilitate comparison and filtering of the growing number of samples tested, all past and current reflectivity data is being added to a Filtergraph portal, accessible at https://instrumentation.tamu.edu/reflectivity-filtergraph

## CONCLUSION

We have presented additional total reflectance measurements of various materials that have been —or may be—used to minimize stray and scattered light within optical and near-infrared astronomical instruments. Control of stray light within an instrument is an important concern and the material choice and surface treatment within the instrument requires careful consideration. Information about the samples including reflectivity plots and text files of the calibrated data will be made available on the Munnerlyn Astronomical Instrumentation site at https://instrumentation.tamu.edu/instruments/reflectance/ as well as the new Filtergraph portal. The same page includes information on how to suggest or submit a sample for testing. Due to resource availability no guarantee is made on sample testing turn around time and results will be made public on our website. We are also unable to return any samples that are submitted for testing.


[1]Marshall et al. 2014, Proc. SPIE, https://doi.org/10.1117/12.2056729
[2]Schmidt et al. 2018, Proc. SPIE https://doi.org/10.1117/12.2312359
[3]Schmidt et al. 2018, Proc. SPIE https://doi.org/10.1117/12.2312365
[4]Schmidt et al. 2020, Proc. SPIE https://doi.org/10.1117/12.2562759
[5]Burger et al. 2013, https://doi.org/10.1016/j.ascom.2013.06.002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